

MERCURY SAMPLING REPORT

August 10-15, 1978

Spec. 1500-11-11
Spaulding
Director, S&A Division

82426

INTRODUCTION

Sampling for ambient mercury was conducted for the State of New Jersey by the Environmental Monitoring and Support Laboratory (EMSL)/RTP in Woodridge, New Jersey from August 10-15, 1978. This monitoring study was initiated as the result of Region II requesting technical assistance from the Environmental Monitoring and Support Laboratory, Research Triangle Park, NC.

MONITORING

A. General

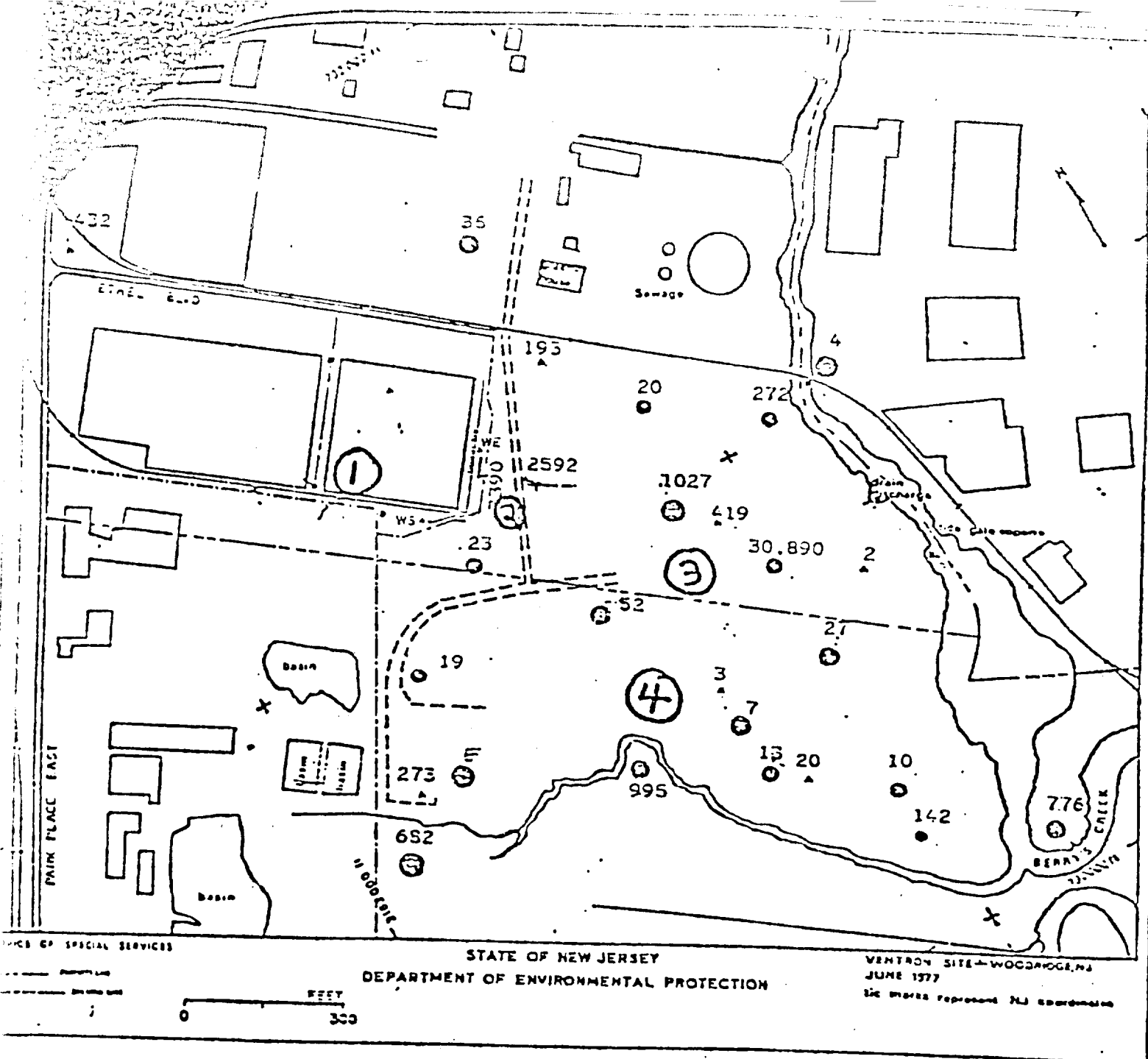
Monitoring was conducted in several locations on a 40 acre site. The majority of the 40 acres were undeveloped and were heavily overgrown with tall (approximately 5 feet) weeds. Approximately 9 of the 40 acres were paved and contain warehouse and office buildings. Sampling was conducted at four (4) sites representing various areas within the 40 acres. See Figure 1 for site locations.

Two types of sampling systems were used in this study. One consisted of a sampling box which contained four parallel sampling tubes. The other sampling system consisted of an orifice system which contained five parallel sampling tubes. Diagrams showing the two different systems are shown in Figure 2. The samplers collect elemental mercury on silver wool collectors. Prior to the collectors, various devices can be placed in the system to distinguish various forms of mercury. The box samplers were designed with a split manifold system. Part of the air stream flowed through filters directly to the collectors. Since organic mercury compounds are not collected on silver wool, this part of the system collected only elemental mercury. The other part of the air stream passed through a pyrolyzer which converted the organic mercury compounds to elemental mercury. Total Hg (organic and elemental) was collected by this technique. The orifice samplers were designed without an inlet manifold system, therefore they collected only elemental Hg.

B. Specifics

Site 1 -- Site 1 was located on the Wolf property in the west half of the building on the first floor. This site was located several feet from the southwest wall approximately equidistant from the side walls. Sampling was conducted during the work day (8 hours) on August 14 and 15, 1978. Four replicate samples were collected each day. On August 14th a box sampler was operated, while on August 15th an orifice sampler was operated. Due to a shortage of tubes, only four sample tubes were used with the orifice system on August 15, 1978.

A comparison of side-by-side sampling of orifice sample boxes results in values that are relatively close and in all cases, the orifice meter values are higher. The true value for each of these days probably lies somewhere between the box values and the orifice values. Table 1 a comparison of the average values for each sampling system, shows that there is close agreement of value at each site. In this table, the corresponding "12 hour samples" were averaged using a time based weighted average. Note that in all cases, the orifice meter sampling systems values are higher than the box samplers as predicted.



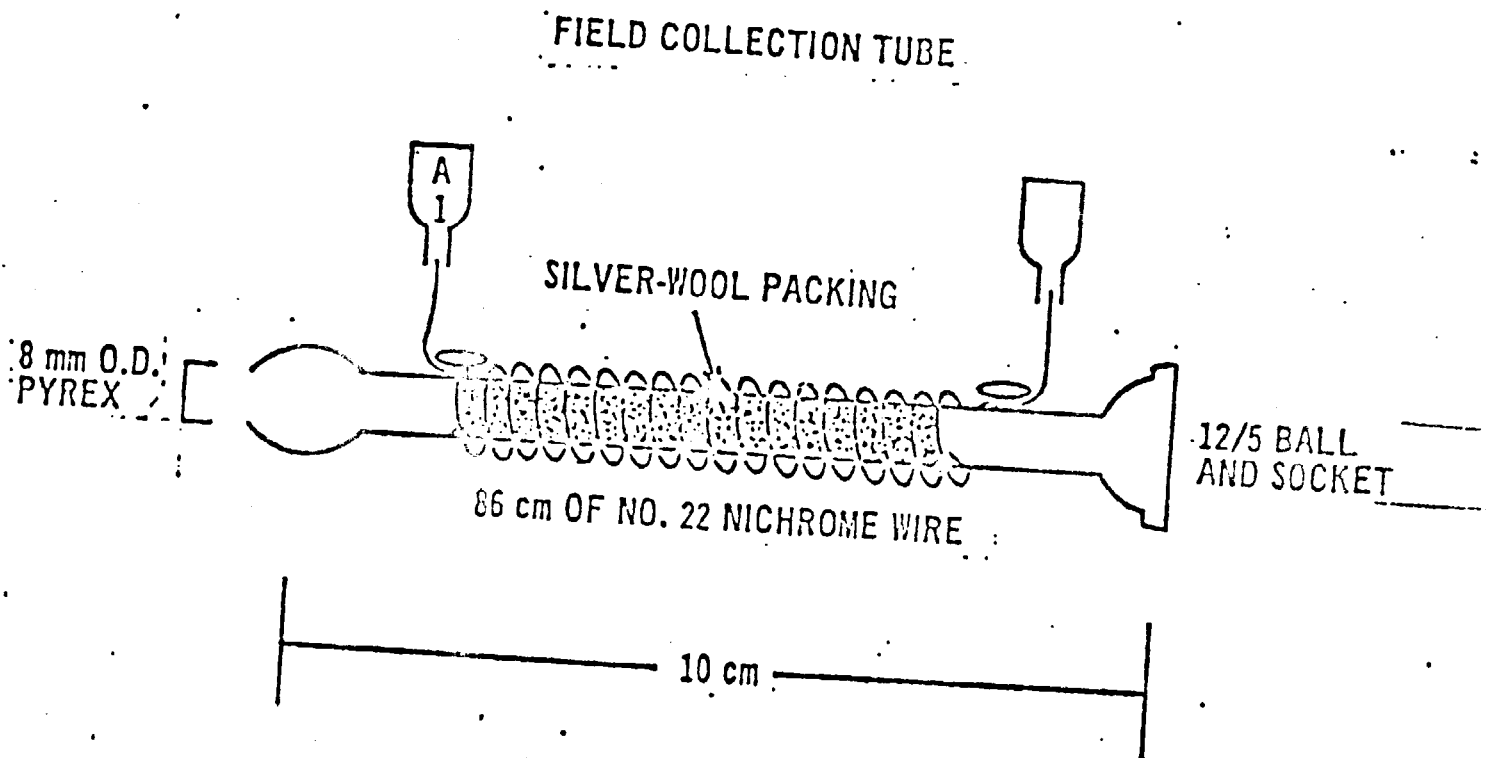
● Soil Station

▲ Observation Well

■ Surface Water Station

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FIGURE 3



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TABLE 1

Site 3 Average Values
ng/m³

Sampling Period	"24 hr" Box Sampler	"24 hr" Orifice	Weighted Average of 2 "12 hr Box Sampler"
8/11-12/78	290.5	296.8	231.6
8/12-13/78	264.8	386.4	343.0
8/13-14/78	750.7	1019.0	844.2

Site 2 Average Values

Sampling Period	Weighted Average of 2 "12 hr Box Sampler Values"	"24 hr" Orifice Sampler
8/11-12/78	417.6	462.6
8/12-13/78	410.9	522.5
8/13-14/78	754.5	1012.8

"12 hr" Box Sampler

"12 hr Orifice"

8/14/78

1541.3

1651.2

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TABLE 2
MERCURY SAMPLING
RAW DATA

Site No.	Date(s)	Sampling Period	Mean ng/m ³	Values ng/m ³
1	8/14/78	900-1646 D	382.25 B	396, 330, 372, 381
1	8/15/78	817-1622 D	738.00 O	731, 748, 763, 710
2	8/10-8/11/78	2121-2027	1021.6 O	583, 954, 1141, 1230, 1200
2	8/11/78	1010-2050 D	551.25 B	573, 600, 486, 546
2	8/11-8/12/78	2032-1947	462.60 O	396, 501, 502, 434, 476
2	8/11-8/12/78	2055-0900 N	471.67 B	427, 494, 494
2	8/12/78	908-1947 D	357.00 B	436, 460, 175
2	8/12-8/13/78	2045-2000	522.5 O	598, 278, 17, 615, 599
2	8/12-8/13/78	2045-826 N	379.00 B	372, 349, 366, 429
2	8/13/78	830-2000 D	443.25 B	432, 497, 431, 413
2	8/13-8/14/78	2015-1954	1012.80 O	1191, 854, 885, 952, 1182
2	8/13-8/14/78	2015-803 N	788.00 B	822, 695, 787, 848
2	8/14/78	807-1954 D	721.00 B	702, 814, 647
2	8/14-8/15/78	2001-800 N	1541.25 B	1708, 1340, 1423, 1694
2	8/14-8/15/78	2001-800 N	1651.20 O	1720, 1536, 2023, 1291, 1692
3	8/10-8/11/78	2037-817 N	1678.40 O	2176, 869, 1723, 2089, 1535
3	8/11-8/12/78	926-740	290.50 B	277, 295, 296, 294
3	8/11-8/12/78	900-740	296.8 O	321, 281, 314, 238, 280
3	8/11/78	921-1936 D	213.75 B	186, 200, 241, 228
3	8/11-8/12/78	1945-740 N	247.25 B	203, 335, 102, 349
3	8/12-8/13/78	820-737	386.40 O	399, 380, 382, 360, 411
3	8/12-8/13/78	800-737	264.75 B	235, 302, 179, 343
3	8/12/78	800-1930 D	179. B	230, 236, 71
3	8/12-8/13/78	1936-737 N	500.00 B	511, 495, 520, 474
3	8/13-8/14/78	847-820	1019.00 O	996, 1029, 1010, 1163, 897
3	8/13-8/14/78	847-820	750.67 B	869, 604, 779
3	8/13/78	847-1937 D	382.00 B	357, 382, 411, 378
3	8/13-8/14/78	1939-820 N	1272.75 B	1356, 1331, 926, 1478
3	8/14-8/15/78	820-738	2396.50 B	2924, 1869
3	8/14-8/15/78	820-738	2846.00 B	2976, 2629, 2933
3	8/14/78	820-1213	607.00 B	597, 617
3	8/14/78	820-1932 D	996.00 O	1056, 947, 985
3	8/14-8/15/78	1938-728 N	3259.33 O	3052, 3911, 2815
4	8/12-8/13/78	930-812	195.25 B	198, 198, 187, 198
4	8/13-8/14/78	820-915	2085.25 B	1252, 2702, 2274, 2113
4	8/14-8/15/78	922-722	2210.00 B	3922, 1532, 1176

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TABLE 3

DATA SUMMARY TABLE

Location	Dates	24-hour Values*	12-hour Values*	8-hour Values*
Site 1	8/14/78 8/15/78			332.2 733.0
Site 2	8/10-11/78 8/11-12/78 8/12-13/78 8/13-14/78 8/14/78 8/14/78	1021.6 462.6 522.5 1012.8 -- --	-- 471.7 379 788.0 1651.2 1541.3	551.3 357.0 443 721.0 -- --
Site 3	8/10-11/78 8/11-12/78 8/12-13/78 8/13-14/78 8/14-15/78	-- 290.5 296.8 386.4 264.8 1019.0 750.67 2846.0 2396.5	-- 213.8 179 382 996	1678.4 247.2 500.0 1272.8 3259.3
Site 4	8/12-13/78 8/13-14/78 8/14-15/78	195.2 2085.2 2210.0		

* All values are expressed as ng/m^3 and are average values for that sampling period and system.

824260007

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE: September 21, 1978

SUBJECT: Data Qualification, Mercury Study - New Jersey

FROM: Jack Suggs *JS*
STAB (MD-75)

TO: Ron Drago
Field Studies Section (MD-76)

THRU: Harold Sauls *HS*
Chief, Statistical Design Section

To establish some qualification of the validity of the reported measure of a sample of mercury, quality assurance audits were performed during the quantitative analytical determinations. Instead of being used as "on-line" quality control information for corrective purposes during the analytical phase, the audit determinations were simply recorded along with the ambient sample determinations. Estimates of the analytical bias and imprecision were calculated from the audit data.

QA Data

Each day during the analytical phase, fresh audit samples were prepared covering possibly different ranges (ng) than for other days. Each day different calibration curves were used. Also, field samples were measured which may or may not have been in the range (ng) of the audit values (ng) for that particular day. The audits performed across the entire analytical operation are grouped in Table 1 according to "known" audit values (X) along with analytical determinations (Y). It must be emphasized that analytical determinations corresponding to similar audit values are not repeat determinations using a given calibration curve. In fact, an audit showing the same value as a field sample may have been prepared on a different day under different conditions. It is also possible that calibrations were derived several times in one day. The values in Table 1 represent audits on the LDC system and not on the Perkins-Elmer system which was used to measure values above .500 ng.

Table 2 summarizes the audit data for those values only where "repeat" analytical determinations were made.

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TABLE 1. Audits

<u>Audit</u>	<u>Analytical Determination (Y) ng</u>
9.50	
15.25	
16.78	
15.60	
16.61	
14.07	
21.25	
32.75	
43.25	
88.80	
65.30	
54.48	
101.75	
105.60	
98.41	
89.92	
96.77	
140.00	
149.31	
149.49	
172.00	
214.00	
449.21	
436.76	
461.56	
401.72	
473.83	

Linear Regression Equation

$$Y = -.208 + 1.023 X$$

$$r^2 = .99$$

TABLE 2. Summary of Repeated Audit Checks

<u>Audit (X) ng</u>	<u>Average of Anal. det (Y) ng</u>	<u>n</u>	<u>S(Y)</u>	<u>%CV = $\frac{S}{Y}$</u>
14.72	16.33	3	.64	4%
87.58	85.72	6	21.05	25%
88.31	93.35	2	4.84	5%
145.59	149.40	2	.13	.1%
434.34	444.57	5	27.67	6%

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Even though the % coefficient of variation (C.V.) is higher at 87.58 ng., this does not mean that all samples at or near this level are questionable due to analytical variability. What it does imply, however, is that on some days the analytical method was more biased than on other days and if samples on these "bad" days were around 87.58 ng, there is reason to suspect their validity. However, we can't invalidate data on days where 87.58 ng was used as an audit since this would cover practically all samples. Furthermore, at the audit value of 88.31 ng, the coefficient of variation is only 5% based on two analytical determinations.

Therefore an average of coefficients of variation was calculated to be 8%. Combining this with the bias 2.3% from slope of the regression equation gives an estimate of the root mean square error of 8.34%.

Roughly, two out of three measurements should lie within 8.34% of their average based on error in the analytical method alone.

Field Samples

Samples taken on the same manifold at a particular site, date and sampling period were randomly analyzed. Therefore, side by side samples may have been analytically measured on different days using different calibration curves subjected to different QA audit values that may or may not have included the sample value in the range of audits. Since the audits were not being used for quality control, no corrective action based on audits was taken during the analytical phase. This means that the sample-to-sample variation expressed as %CV in Table 3 contains variation in the field sampling phase as well as the analytical phase.

An average coefficient of variation for sample-to-sample variation is estimated from the last column in Table 3 to be approximately 17%.

Roughly we can say that 20% of the sample-to-sample variation is attributable to analytical error.

Some of the high %CVs at levels above 500 ng (identified by * in Table 3) can be partly attributed to analytical variation. At these levels the Perkins-Elmer system was used and the audit values are given as:

<u>Audit (X) ng</u>	<u>Analytical (Y) ng</u>	<u>% CV</u>
847.5	716.5	16%
847.5	898.7	
833.6	Below zero	

TABLE 3. Mercury Data Summary and Statistics

Site	Sampling Date	Sampling Period	Sample Size (n)	Average (\bar{X}) ng/m ³	Standard Deviation (s)	% C.V. = $\frac{s}{\bar{X}} \times 100$
1-inside	8/14/78	0300-1646	4	382.25	10.01	3
	8/14/78	0817-1622	4	738.00	22.79	3
2-orifice	8/10/78	2121-2027	5	1021.60	267.61	26
	8/11/78	2032-1947	5 ^a	462.60	46.32	10
	8/12/78	2045-2000	4	522.50	163.19	31
	8/13/78	2015-1954	5	1012.80	162.50	16
	8/14/78	2001-0800	5	1651.20	268.82	16
2-Box G	8/11/78	2055-0900	3	471.67	38.68	8
		1010-2050	4	551.25	48.77	9
	8/12/78	0908-1947	4	357.00	158.07	44
		2045-826	4	379.00	34.73	9
	8/13/78	2015-0803	4	788.00	66.85	8
		0830-2000	4	433.25	36.88	8
	8/14/78	2001-0800	4	1541.25	187.64	12
		0807-1954	3	721.00	85.11	12
3-Orifice	8/10/78	2037-0817	5	1678.40	522.94	31
	8/11/78	0900-0740	5	296.80	19.31	7
	8/12/78	0820-0737	5	386.40	19.50	5
	8/13/78	0847-0820	5	1019.00	95.30	9
	8/14/78	0820-0728	3	2846.00*	189.15	7
3-Box D	8/11/78	1945-0740	4	247.25	117.06	47
		0921-1936	4	213.75	25.20	12
	8/12/78	1936-0737	4	500.00	20.18	4
		0800-1930	3	179.00	93.58	52
	8/13/78	1919-0820	4	1272.75	239.92	19
		0847-1937	4	382.00	22.30	6
	8/14/78	0820-0738	2	2396.50	746.00	31
		0820-1213	2	607.00	14.14	2
3-Box A	8/11/78	0926-0740	4	290.50	9.04	3
	8/12/78	0800-0733	4	264.75	72.45	27
	8/13/78	0847-0820	4	750.67	134.75	18
	8/14/78	0820-1932	3	996.00	55.33	6
		1938-0720	3	3259.33*	576.67	18
4-Box F	8/12/78	0930-0812	4	195.25	5.50	3
	8/13/78	0820-0915	4	2085.25	608.57	29
	8/14/78	0922-0722	3	2210.0*	1493.0	68

Avg. (%CV) = 17.19

^aDixon Ratio Test indicated that 17 ng/m³ is an outlier among 5 values of 598, 278, 17, 615, 599 ng/m³ and was excluded from analysis.

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For field samples above 500 ng., the average % CV is 31%. Therefore, at values above 500 ng., we can estimate roughly that 27% of the sample-to-sample (in ng/m³) variation is attributable to analytical error. On the average this is double the error observed at levels below 500 ng. The bias at this level is about -5.0%.

cc: Gerry Akland, MD-75
 J. Puzak, MD-77
 S. Long, MD-78

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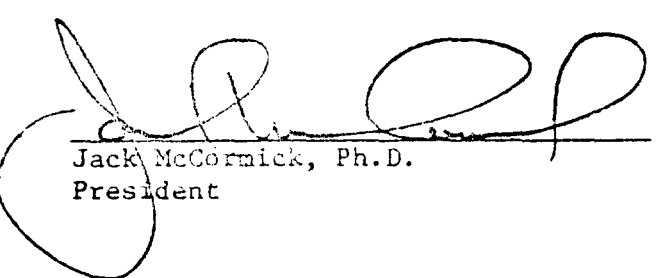
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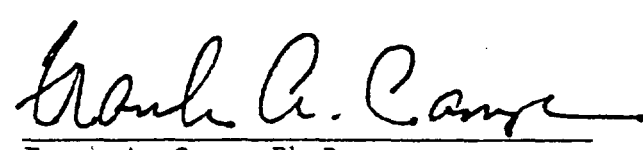
1 August 1977

INVESTIGATIONS OF AQUATIC AND TERRESTRIAL
MERCURY CONTAMINATION IN THE VICINITY OF THE
FORMER LOCATION OF THE WOOD-RIDGE
CHEMICAL CORPORATION PROCESSING PLANT,
BOROUGH OF WOOD-RIDGE AND CARLSTADT,
BERGEN COUNTY, NEW JERSEY

Submitted to: Office of the Commissioner
New Jersey Department of
Environmental Protection
Labor and Industry Building
Trenton, New Jersey 08625



Jack McCormick, Ph.D.
President



Frank A. Camp, Ph.D.
Vice President

824260013

Biological and Chemical
Water Analyses and Monitoring

Inventories of Vegetation
and Wildlife Resources

Socio-economic
Surveys and Analyses

Environmental
Impact Analysis

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1. INTRODUCTION

1.1. Purpose

This report contains the results of an investigation of the concentrations of mercury in soil, groundwater, surface water, and sediment on, and in the vicinity of, the site formerly occupied by a chemical manufacturing plant in the Borough of Wood-Ridge, New Jersey. The purpose of the investigation was to determine if the site currently is contributing mercury to the aquatic environment to West Riser Ditch of Berrys Creek.

The procedures used in this investigation were discussed with, and approved by, personnel of the New Jersey Department of Environmental Protection before the initiation of the fieldwork. Personnel from the Department were present during most of the time that work was conducted on the site by the contractor. All deviations from the scope of work as originally proposed were made with the approval, or at the recommendation, of personnel from the Department.

1.2. Location of the Subject Site

The Subject Site is located in the Borough of Wood-Ridge and in the Borough of Carlstadt, County of Bergen, State of New Jersey (Figure 1). The Site includes properties that currently are owned by the United States Life Insurance Company, Robert and Rita Wolf, operating as Wolf Realty, and the Velsicol Chemical Corporation. These properties are identified on Figure 2. Also identified on Figure 2 are the sampling locations for surface water (and sediment), groundwater, and soil. Soil sampling locations remote from the Subject Site are identified on Figure 1.

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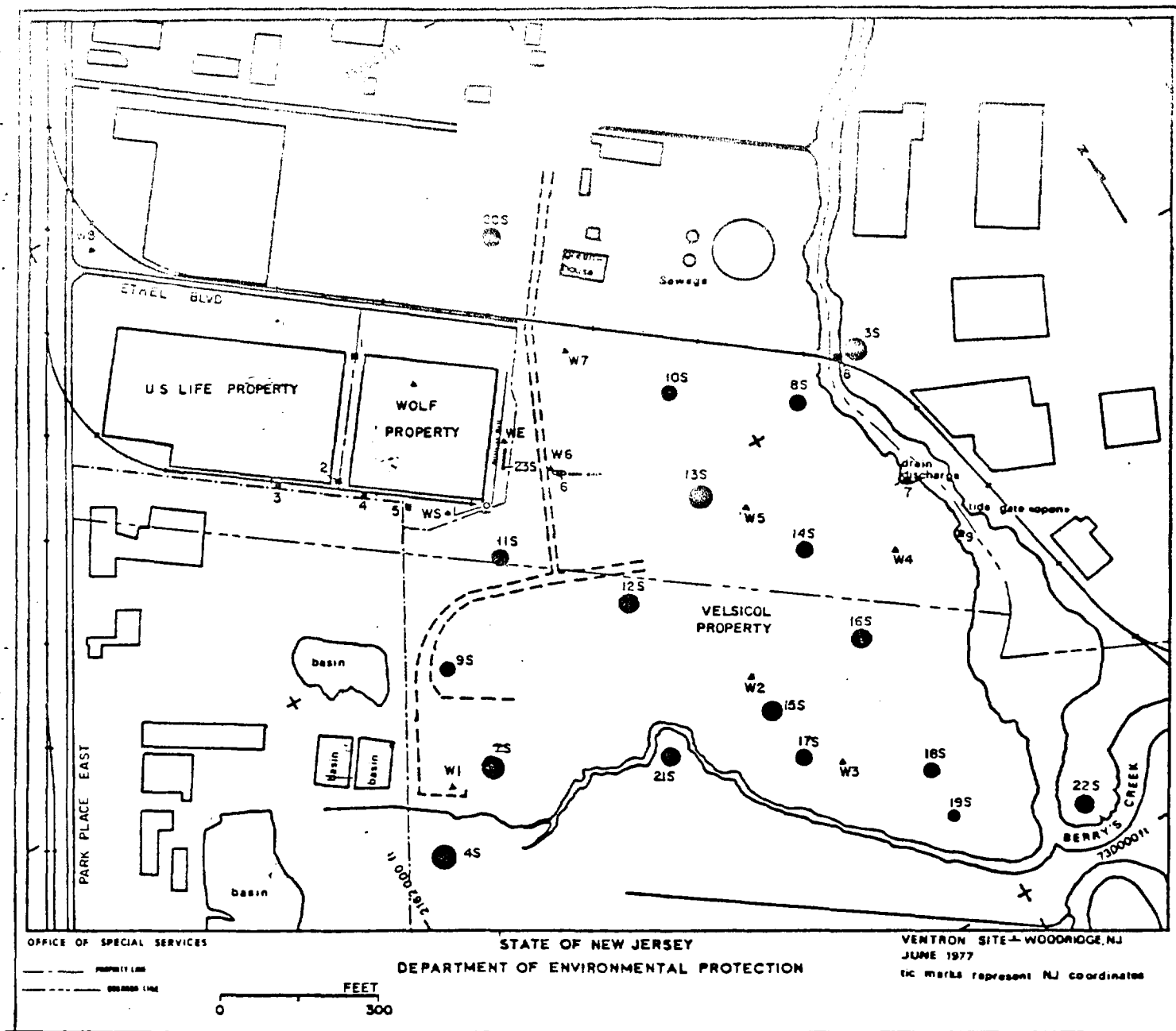


Figure 2. Locations of surface water stations, observation wells, and soil stations on and near the subject site.

2. CHRONOLOGY OF EVENTS AT THE SUBJECT SITE

The following narrative sections are summaries of information obtained from the County of Bergen, Office of the County Clerk, Division of Records, Hackensack, New Jersey (Section 2.1.), and from a file of documents assembled by the Attorney General of New Jersey. An index to the sources of information regarding the ownership of all or parts of the Subject Site is presented as Table 1. Documents from the file of the Attorney General are listed according to their origin and, secondarily, in chronologic order in Table 2. A unique alphanumeric code is associated with each document in the table, and the codes are used in this narrative to cite specific documents.

2.1. History of Ownership

On 17 June 1929, the Carlstadt Development and Trading Company, a Maryland Corporation with its business offices in New York, New York, leased an irregularly shaped parcel of property located within the Boroughs of Wood-Ridge and Carlstadt, County of Bergen, State of New Jersey, to the F. W. Berk and Co., Inc., also a Maryland corporation. Signing the lease for F. W. Berk and Co., Inc., were Messrs. P. F. Berk, President, and W. R. Britton, Secretary. The property is listed on current tax maps as Block 229, Lots 10A and 10B. Easements for utilities and roadways now adjacent to Lots 10A and 10B were included in the parcel that was leased during 1929. =

From at least 1927, F. W. Berk and Co., Inc., was wholly owned by Steetly, Inc., a firm registered in England. Between 1948 and 1949, the company was sold to Agil, Inc., which then sold its interests to a Mr. George Taylor during the early 1950's. Prior to this, however, the F. W. Berk and Co., Inc., purchased all lands leased from the Carlstadt Development and Trading Co. on 28 December 1943. On 1 June 1952, a portion of the property which included a structure known as the Zirconium Building, was leased to the Melberk Co., Inc., a New Jersey corporation. Signing the lease for F. W. Berk and Co., Inc., was Mr. George Taylor. On 12 March 1953, F. W. Berk and Co., sold an easement to the Hackensack Water Company. An easement was sold to the Public Service Electric and Gas Company on 7 October 1955. On 22 December 1955, the Magnesium Elektron Corporation (formerly Melberk, Inc.) terminated its lease with F. W. Berk and Co. During or shortly after 1956, the F. W. Berk and Co. industrial premises became known as Wood-Ridge Chemical Co.

During 1960, the F. W. Berk and Co. corporation was dissolved, and the property was sold to the Wood-Ridge Chemical Corporation (WRCC) which was wholly owned by the Velsicol Chemical Corporation. The Wood-Ridge Chemical Corporation sold a parcel of land to Julius Blum and Company, Incorporated, on 2 September 1965. Another parcel was sold to the Borough of Wood-Ridge on 29 June 1967. During 1967, the remainder of the property owned by the Wood-Ridge Chemical Corporation, which was registered in Nevada, was sold to the Velsicol Chemical Corporation. In 1968, a portion of the property was resold to the

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Table 1. The locations of records of ownership transactions in the Office of the County Clerk, County of Bergen, State of New Jersey.

Date	Transaction	Book	Page
3 April 1888	Sold by East River National Bank to Melchior Helbig	K-12	345
7 August 1893	Sold by East River National Bank to Melchior Helbig	365	211
9 November 1917	Sold by Abram DeBaun to John Storms	1462	259
22 April 1929	Sold by John B. and Bertha Q. C. Storms to Carlstadt Development and Trading Company	1641	424
1906	Sold by New York and New Jersey Real Estate and Improvement Company to Frederico Fiore	806	317
28 April 1913	Sold by Frederico Fiore to Earl E. Litz	843	536
30 April 1915	Sold by Earl E. Litz to New Jersey Brick Company	907	89
1 November 1917	Sold by New Jersey Brick Company to Michael J. Martin	974	156
2 July 1921	Sold by Michael J. Martin to Panhard Oil Company	1116	451
7 February 1923	Sold by Panhard Oil Company to Eldorado Construction Company	1189	668
20 April 1929	Sold by Eldorado Construction Company to Carlstadt Development and Trading Company	1641	421
17 June 1929	Leased by Carlstadt Development and Trading Company to F. W. Berk and Company	1649	461
29 December 1943	Sold by Carlstadt Development and Trading Company to F. W. Berk and Company	2413 2413	406 410

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Table 1. Index to the locations of records of ownership transactions in the files of the Office of the County Clerk (concluded).

Date	Transaction	Book	Page
31 July 1952	Leased by F. W. Berk and Company to Melberk, Inc.	3344	207
25 March 1953	Sold by F. W. Berk and Company to Hackensack Water Company	3413	124
7 October 1955	Sold by F. W. Berk and Company to Public Service Electric and Gas Company	3582	451
22 December 1955	Lease from Magnesium Elektron Inc. (formerly Melberk Inc.) to F. W. Berk terminated	3724	422
5 July 1960	Sold by F. W. Berk and Company to Wood-Ridge Chemical Corporation	4139	576
2 September 1965	Sold by Wood-Ridge Chemical Corporation to Julius Blum and Company	4832	20
29 June 1967	Sold by Wood-Ridge Chemical Corporation to Borough of Wood-Ridge	5058	257
29 June 1967	Sold by Wood-Ridge Chemical Corporation to Velsicol Chemical Corporation	5058	261
6 February 1968	Sold by Velsicol Chemical Corporation to Wood-Ridge Chemical Corporation	5142	416
21 May 1974	Sold by Wood-Ridge Chemical Corporation to Robert M. and Rita Wolf	5898	202
20 May 1975	Sold by Robert M. Wolf to United States Life Insurance Company	6003	64
15 December 1975	Leased by United States Life Insurance Company to Robert Wolf	6069	237

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Table 2. Index to records from the file of the Attorney General of New Jersey relative to events at the Subject Site. The documents are arranged according to origin and, secondarily, by date. Each document is identified by a unique alphanumeric symbol that is utilized to cite the document in the accompanying narrative text.

New Jersey Department of Environmental Protection

Symbol	Date	Item
DEP-1	27 October 1970	Memo to Segesser from Clark
DEP-2	24 May 1973	Order from DEP to Ventron
DEP-3	10 June 1974	Telegram to Ottolio from NJDEP
DEP-4	2 July 1974	Letter to Longstreet from United States Testing
DEP-5	14 July 1974	Letter to Longstreet from Polito, EPA
DEP-6	4 October 1974	Memo to Birns from Longstreet
DEP-7	8 August 1975	Telegram to Rovic Construction from Ricci (DEP)
DEP-8	30 July 1974	Chronology prepared by Pike for Longstreet
DEP-9	28 March 1977	Chronology prepared by Longstreet for Heksch
	<u>Data</u>	
DEP-10	14 February 1975	Memo to file from Jacangelo
DEP-11	12 May 1976	Memo to Longstreet from Cotterell
DEP-12	3 November 1976	Memo to file from Longstreet
DEP-13	16 November 1976	Interim Report from Jacangelo

New Jersey Department of Labor and Industry

DLI-1	2 August 1971	Accident report
DLI-2	9 May 1974	Inspection memo from Gomez to Stanton

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Table 2. Index to records from the file of the Attorney General of
of New Jersey relative to events at the Subject Site (continued).

<u>New Jersey Department of Health</u>		
<u>Symbol</u>	<u>Date</u>	<u>Item</u>
DOH-1	9 April 1956	Memo from Wilford and Johns to Shaw
DOH-2	14 May 1956	Memo from Wilford and Conlon to Shaw
DOH-3	17 June 1958	Letter to Wilford from F. W. Berk & Co.
DOH-4	2 December 1958	Memo from Wilford to Shaw
DOH-5	17 March 1959	Memo from Wilford to Shaw
DOH-6	4 February 1960	Inspection report
DOH-7	4 March 1960	Letter to Berk from Shaw
DOH-8	22 March 1960	Letter to Shaw from Berk Co.
DOH-9	9,10 August 1960	Inspection report
DOH-10	15 August 1960	Memo from Hughes to Shaw
DOH-11	25 August 1960	Letter to Hughes from Wood-Ridge Chem.
DOH-12	5 December 1960	Memo to Shaw from Hughes
DOH-13	13 December 1962	Memo to Segesser from Giallella and Hughes
DOH-14	22 January 1963	Memo to Segesser from Hughes
DOH-15	4 February 1964	Letter to Wood-Ridge Chem. from Segesser
DOH-16	6 August 1964	Letter to Wood-Ridge Chem. from Segesser
DOH-17	17 November 1964	Letter to Wood-Ridge Chem. from Segesser
DOH-18	December 1964	Status report to file from Hughes
DOH-19	25 January 1965	Letter to Wood-Ridge Chem. from Segesser
DOH-20	27 January 1965	Letter from W.R.C.C. to Hughes
DOH-21	4 March 1965	Surveillance Report

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Table 1. Index to records from the file of the Attorney General of New Jersey relative to events at the Subject Site (continued).

New Jersey Department of Health (continued)

Symbol	Date	Item
DOH-22	10 May 1965	Letter from W.R.C.C. to Hughes
DOH-23	16 June 1965	Letter from Segesser to W.R.C.C.
DOH-24	18 June 1965	Letter to Hughes from W.R.C.C.
DOH-25	2 March 1966	Surveillance Report
DOH-26	3 March 1966	Surveillance Report
DOH-27	18 April 1966	Letter to W.R.C.C. from Hughes
DOH-28	4 April 1966	Letter from Hughes to W.R.C.C.
DOH-29	1 March 1967	Surveillance Report
DOH-30	19 April 1967	Field Inspection
DOH-31	<u>19 April 1967</u>	Surveillance Report
DOH-32	21 October 1967	Surveillance Report
DOH-33	30 October 1967	Surveillance Report
DOH-34	21 December 1967	Field Inspection
DOH-35	21 December 1967	Field Inspection
DOH-36	1 February 1968	Letter to W.R.C.C. from NJDOH (Clark)
DOH-37	13 February 1968	Letter to W.R.C.C. from Hughes
DOH-38	13 March 1968	Surveillance Report
DOH-39	14 March 1968	Letter to Hughes from W.R.C.C.
DOH-40	26 March 1968	Letter to W.R.C.C. from Clark NJDOH
DOH-41	13 April 1968	Letter to NJDOH from W.R.C.C.
DOH-42	20 May 1968	Surveillance Report
DOH-43	20 May 1968	Field Inspection

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Table 2. Index to records from the file of the Attorney General of New Jersey relative to events at the Subject Site (continued).

New Jersey Department of Health (continued)

<u>Symbol</u>	<u>Date</u>	<u>Item</u>
DOH-44	24 May 1968	Letter to NJDOH from W.R.C.C.
DOH-45	17 June 1968	Letter to NJDOH from W.R.C.C.
DOH-46	16 July 1968	Surveillance Report
DOH-47	4 September 1968	Letter to NJDOH from W.R.C.C.
DOH-48	21 October 1968	Letter to W.R.C.C. from Hughes
DOH-49	29 October 1968	Letter to NJDOH from W.R.C.C.
DOH-50	14 February 1969	Memo to file from Hughes
DOH-51	14 April 1969	Letter to W.R.C.C. from NJDOH
DOH-52	17 April 1969	Letter to NJDOH from W.R.C.C.
DOH-53	7 March 1977	Memo to file from Marshall

Data

DOH-54	16 July 1974	Letter to HMDC from NJDOH
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United States Environmental Protection Agency

EPA-1	28 December 1970	Memo from Bromberg to Deputy Regional Director
EPA-2	15 February 1971	Memo from Cianca to Stein
EPA-3	6 May 1971	Memo from Cianca to Bennett
EPA-4	14 June 1971	Letter to Faye (Ventron) from Roy
EPA-5	7 June 1974	Memo to file from Librizzi
EPA-6	7 June 1974	Field notes by Ewe Frank
EPA-7	11 June 1974	Memo to file from Librizzi
EPA-8	June 1974	Memo from Jeleniewski to Librizzi

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Table 2. Index to records from the file of the Attorney General of New Jersey relative to events at the Subject Site (continued).

United States Environmental Protection Agency (continued)

<u>Symbol</u>	<u>Date</u>	<u>Item</u>
EPA-9	29 July 1974	Memo from Lindsey to Polito
EPA-10	16 August 1974	Memorandum of Understanding
EPA-11	28 February 1975	Letter to Rovic Construction from Sconnik
EPA-12	25 July 1975	Letter to Polito from Atlantic Richfield Co.
EPA-13	12 August 1975	Memo to file from Polito
EPA-14	20 August 1975	Memo to Gluckstern from Polito
EPA-15	undated	Chronology written by Librizzi
EPA-16	10 November 1976	Chronology written by Polito for Longstreet
EPA-17	6 April 1977	Report prepared by Rogers
EPA-18	28 April 1977	Chronology written by Polito for Librizzi
<u>Data</u>		
EPA-19	28 August 1970	FWQA, U.S. Department of the Interior memo
EPA-20	1 October 1970	FWQA memo to file - Enforcement
EPA-21	21 October 1970	Memo to chief, operations from Brezenski
EPA-22	October 1970	FWQA - memo
EPA-23	23 March 1971	Memo from Brezenski, Lab results
EPA-24	5 November 1971	Memo from Brezenski, Lab results
EPA-25	19 June 1974	Memo from Brezenski, Lab results
EPA-26	19 June 1974	Memo from Brezenski, Lab results
EPA-27	28 June 1974	Memo from Brezenski, Lab results
EPA-28	3 July 1974	Letter to Longstreet from Polito
EPA-29	8 August 1974	Letter from U.S. Testing to Polito

Table 2. Index to records from the file of the Attorney General of New Jersey relative to events at the Subject Site (continued).

United States Environmental Protection Agency (continued)

<u>Symbol</u>	<u>Date</u>	<u>Item</u>
	<u>Data</u>	
EPA-30	8 August 1974	Memo from Brezenski
EPA-31	13 September 1974	Memo from Brezenski
EPA-32	27 September 1974	Memo from Brezenski
EPA-33	30 September 1974	Memo to Gluckstern from Polito
EPA-34	20 August 1975	Memo to Polito from Brezenski
EPA-35	5 November 1975	Memo to Polito from Brezenski
EPA-36	20 September 1976	Letter to Jacangelo from Brezenski
EPA-37	2 May 1977	Chronology of sample receipts from Brezenski

F. W. Berk and Company

FWB-1	22 September 1959	Report from Grich, Inc. to Berk
FWB-2	undated	Report from Grich, Inc. to Berk

Ventron Memoranda and Letters

VE-1	2 February 1968	Memo to J. Bratt from E. A. Clark
VE-2	23 September 1970	Memo from Faye to Bernstein
VE-3	28 September 1970	Memo from Cadmus to Faye
VE-4	28 October 1970	Memo from Hoffman to Bernstein
VE-5	9 November 1970	Memo from Bernstein to Hoffman
VE-6	11 November 1970	Memo from Bernstein to Hoffman

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Table 1. Index to records from the file of the Attorney General of New Jersey relative to events at the Subject Site (continued).

Ventron Memoranda and Letters (continued)

Symbol	Date	Item
VE-7	4 February 1971	Letter to NJDEP from Myskowski
VE-8	11 February 1971	Memo from Bernstein to Hoffman
VE-9	22 February 1971	Lab instructions to Magier from Cadmus
VE-10	undated	Memo to Wilson from Faye
VE-11	22 February 1971	Memo to Cadmus from Wilson
VE-12	31 March 1971	Letter to Ventron from NJDEP
VE-13	5 April 1971	Memo to Bernstein <u>et al.</u> from Myskowski
VE-14	undated	Memo to Hoffman from Myskowski
VE-15	4 June 1971	Letter to Bennett, EPA from Bernstein
VE-16	8 June 1971	Letter to Bernstein from Bennett, EPA
VE-17	30 June 1971	Application for discharge permit to US Army, Corps of Engineers
VE-18	20 July 1971	Memo from Faye to Bernstein <u>et al.</u>
VE-19	22 July 1971	Letter to Bennett, EPA, from Bernsein
VE-20	29 July 1971	Letter to Gelberman, US Army, Corps of Engineers
VE-21	17 August 1971	Letter to Bennett, EPA, from Faye
VE-22	24 August 1971	Letter to Faye from Bennett
VE-23	26 August 1971	Letter to Bennett from Bernstein
VE-24	31 August 1971	Letter to Bennett from Faye
VE-25	20 September 1971	Memo from Wilson to Bernstein
VE-26	27 September 1971	Letter to Faye from Bennett
VE-27	12 October 1971	Letter to Bennett from Hoffman

Table 2. Index to records from the files of the Attorney General of New Jersey relative to events at the Subject Site (continued)

Wolf & Rovic Correspondence and Memoranda (continued)

Symbol	Date	Item
WV-6	20 August 1974	Wolf Memo
WV-7	29 November 1974	Letter to Rovic from Coast Guard
WV-8	26 December 1974	Letter to Wolf from Greater New York Insurance
WV-9	30 September 1975	Letter to Wolf from Arthur Anderson Co.
WV-10	8 March 1976	Letter to Heksch from Rodberg.
<u>Soils Testing</u>		
WV-11	11 March 1974	Letter from Joseph S. Ward, Inc. (JSW) to Rovic
WV-12	May 1974	Report on Soils from JSW to Rovic
WV-13	23 May 1974	Letter from JSW to Rovic
WV-14	13 August 1974	Letter with report from U.S. Testing Co. to Rovic
WV-15	15 August 1974	Letter with report from U.S. Testing Co. to Rovic
WV-16	29 August 1974	Letter from U.S. Testing to Rovic.
WV-17	16 September 1974	Letter with report from JSW to Rovic
WV-18	26 September 1974	Report from Jersey testing lab. to Rovic
WV-19	1 October 1974	Report from Jersey testing lab. to Rovic
WV-20	17 November 1975	Letter form JSW to Rovic
WV-21	2 January 1975	Letter from JSW to Rovic
WV-22	28 January 1975	Report from U.S. Testing to Rovic
WV-23	28 January 1975	Report from U.S. Testing to Rovic
WV-24	28 January 1975	Report from Jersey testing lab. to Rovic
WV-25	29 January 1975	Letter from JSW to Rovic

Table 2. Index to records from the file of the Attorney General of New Jersey relative to events at the Subject Site (concluded).

Wolf & Rovic Correspondence and Memoranda (continued)

<u>Symbol</u>	<u>Date</u>	<u>Item</u>
<u>Recovery of Mercury</u>		
WV-26	6 November 1974	Letter from Johnson to Rovic
WV-27	30 December 1974	Letter from Ollis to Rovic
WV-28	9 January 1975	Letter from Johnson and Ollis to Rovic
WV-29	29 January 1975	Wolf Memo
WV-30	4 March 1975	Ollis and Johnson report to Wolf
WV-31	28 February 1975	Letter from Hazen Research Inc. to Wolf
WV-32	4 April 1975	Report from Hazen Research Inc. to Wolf
WV-33	4 August 1975	Report from Hazen Research Inc. to Wolf
<u>Data</u>		
WV-34	1975	Report from Jersey testing lab. to Rovic

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5-day BOD and suspended solids on samples of various effluents collected on 8 December 1953 by a representative of the Metropolitan State Health District (DOH-1). During a subsequent visit on 27 April 1956 by Messrs. Wilford and Conlon, NJDOH, to the F. W. Berk and Company, a series of grab and composite samples were collected from the effluents of the three buildings of concern, the combined effluent, and the watercourse prior to the effluent discharge point. Various analyses were performed on the samples but none for mercury compounds. By reason of high suspended solids and BOD values, the discharge was described as unacceptable (DOH-2).

In a letter of 17 June 1958 from F. W. Berk and Company to NJDOH, the Department was advised that the Borough of Wood-Ridge Sewage Treatment plant's operating engineer had indicated that wastes from the Company would not be accepted for at least one year due to the necessity to operate the plant in excess of capacity levels (DOH-3). Any proposed connection, however, would require pretreatment of the industrial wastes. In December 1958, the company was visited again by Mr. Wilford, NJDOH, and four terms of agreement were reached: 1) a written statement would be obtained by F. W. Berk and Company regarding acceptance of wastes by the Wood-Ridge Sewage Treatment plant with or without pretreatment; 2) if pretreatment was required, efforts to construct pretreatment facilities would commence regardless of the stage of expansion of the Wood-Ridge treatment plant; 3) if discharge to the treatment plant was denied, services of a consulting engineer would be engaged to study wastes and submit designs for on-site treatment; and 4) the Department would be kept informed of progress with quarterly reports to the end that a positive solution was expected within one year (DOH-4). The next visit to F. W. Berk and Company by Mr. Wilford occurred on 17 March 1959, concurrent with a visit to Mr. Ronald Brown, Municipal Engineer for the Borough of Wood-Ridge (DOH-5). It was expressed that the Borough was reluctant to accept wastes from F. W. Berk and Company owing to the toxic effect on the biological processes at the treatment plant, even with pre-treatment. Nonetheless, the Company was expected to obtain an independent evaluation of its wastes before any consideration could be given to the request for discharge to the Wood-Ridge Sewage Treatment Plant. Additionally, the Company was studying further methods to remove mercury compounds from the final effluent.

In September 1959, a report prepared for F. W. Berk and Company by Edward R. Grich, Inc., revealed that the unfavorable physical and chemical characteristics of the industrial effluent in an 8-hour composite sample were low pH, excessive acidity concentration, high turbidity and color, and high suspended solids concentration (FWB-1). The report noted surprisingly low BOD and COD values and relatively high concentrations of dissolved salts such as sulfates and nitrate-nitrogen. Recommendations for treatment of the wastes also were included in the report. In November 1959, the Borough of Wood-Ridge advised F. W. Berk and Company that its request to discharge industrial wastes into the municipal sewerage system had been denied (DOH-6). In February 1960, an inspection of F. W. Berk and Company premises was made by representatives of NJDOH, and samples were collected from three separate effluents and a combined final effluent to Berrys Creek. No evidence of mercury compounds could be found in any of the effluent

samples (DOH-6). This was the first known occasion that the effluent was measured for mercury. The inspection report concluded that the final effluent was unacceptable for discharge to Berrys Creek due to excessive levels of BOD, pH, and suspended solids. The report also concluded that, based on the analytical results, the wastes would not exert a marked deleterious effect on the biological processes of a sewage treatment plant. A subsequent letter of 4 March 1960 to F. W. Berk and Company, Inc. from NJDOH warned that a formal order would be served to insure compliance with existing legislation if no treatment of the industrial wastes progressed immediately (DOH-7). F. W. Berk and Company responded on 22 March 1960 indicating that negotiations with the Borough of Wood-Ridge were on-going and that professional designs for a treatment plant were being sought (DOH-8).

2.4. Communications Between Wood-Ridge Chemical Corporation and the State of New Jersey (1960 to 1970)

In August 1960, a letter to NJDOH from Wood-Ridge Chemical Corporation, successor to F. W. Berk and Company, Inc., indicated that WRCC was aware of the unacceptable quality of the effluents and listed specific plans for treatment of effluents before and after their combination to a final effluent (DOH-11). The letter was sent following an inspection by NJDOH on 9 and 10 August 1960 (DOH-9). No samples were collected during the August 1960 inspection.

In December 1960, NJDOH inspected the WRCC premises and found that all plans for treatment of industrial wastes outlined in their August 1960 letter had been effected (DOH-12). A grab sample of the final effluent was collected near the discharge on 3 November 1960 and revealed high turbidity, suspended solids, and low dissolved oxygen. No measurements for mercury compounds were made (DOH-12). An inspection of the WRCC premises again was made in December 1962, but no samples were collected (DOH-13). In January 1963, WRCC advised NJDOH that Clinton-Bogert Associates was retained to design industrial waste treatment facilities (DOH-14). In February 1964, NJDOH requested WRCC to report on its progress with plans for its industrial waste treatment (DOH-15). In a letter to WRCC from NJDOH dated 6 August 1964, treatments proposed in a February 1964 report from Clinton-Bogert Associates were summarized and confirmed, and WRCC was directed to submit final plans and specifications and a formal application for approval (DOH-16).

On 2 November 1964, WRCC advised NJDOH of construction of an 8-inch tile sewer and collecting sump for separation of process water from cooling water (WRCC-3). Before final planning for treatment, however, WRCC advised that testing of the separated process waters would be necessary in order to properly design the treatment plant. Construction of the plant effluent sewer and collecting sump was completed in January 1965, and at that time WRCC was expected to complete studies for treatment of the more concentrated effluent so that treatment would be effected by July 1965. In May 1965, WRCC sent a progress report to NJDOH indicating initial success in pilot plant treatment tanks (DOH-22). A surveillance report on effluent samples

from WRCC in March 1965 contained no measurements for mercury compounds, but indicated high values for turbidity, color, and BOD which resulted in dissolved oxygen concentrations of zero. A surveillance report on effluent samples from WRCC in March 1966 indicated very high values for COD, color, turbidity, BOD, and suspended solids (DOH-25, 26). No measurements were made for dissolved oxygen or mercury compounds. In April 1966, WRCC sent a copy of a report by E. R. Grich, Inc., to NJDOH summarizing work performed for development of suitable waste treatment procedures (WRCC-4). A NJDOH surveillance report of WRCC in March 1967 indicated very poor conditions on the premises (DOH-29). Effluent samples contained very high values for COD, suspended solids, total solids, turbidity, color, and pH. Additionally, the report noted that wastes entering a holding tank were not pressure filtered as designed but exited the tank via a bypass. Subsequent surveillance reports of the WRCC premises were made on 19 April, 21 October, 30 October, and 21 December 1967, and all indicated unfavorable site conditions and unacceptable analytical results on effluent samples (DOH-30 through 35). On 1 February 1968, a letter was sent to WRCC from NJDOH indicating unfavorable conditions in the discharge and requesting correction of the conditions and notification of such corrections within two weeks (DOH-36).

On 13 February 1968, a confirmation letter was written from NJDOH to WRCC summarizing discussions of 9 February 1968 on the abatement of pollution from WRCC premises (DOH-37). The letter directed WRCC to immediately undertake studies to treat industrial wastes and to draw plans for suitable revisions to existing facilities. Bi-monthly progress reports were required to be submitted to the Water Pollution Control Program. On 13 March 1968, a NJDOH surveillance report indicated that conditions on the WRCC premises remained unchanged (DOH-38).

On 18 April 1968, WRCC sent a progress letter informing NJDOH that Metcalf and Eddy Engineers, Inc., were retained as consultants and outlining a specific program of study to treat the industrial wastes (DOH-41). WRCC sent NJDOH a progress report on 17 June 1968 summarizing work done during the reporting period and included a tentative schedule for accomplishment of objectives regarding the engineers report, construction plans, and completion of construction by November 1969 (DOH-45). On 4 September 1968, a progress report was sent from WRCC to NJDOH, summarizing Metcalf and Eddy's treatment study results and recommendations for treatment (DOH-47). In the interim, surveillance reports of WRCC premises on 20 May and 16 July 1968 indicated that conditions on the premises remained unchanged (DOH-42, 43, 46). On 29 October 1968, WRCC sent NJDOH a letter stating that they were awaiting a final report from Metcalf and Eddy, Inc., which they expect to receive by the end of November 1968 (DOH-49).

In January 1969, WRCC sent a copy of the final report by Metcalf and Eddy to NJDOH and suggested a meeting to discuss future treatment plans. Surveillance reports of the WRCC premises were made by NJDOH representatives on 14 January 1969, 4 March 1969, 27 August 1969, and 24 November 1969 (DEP-8). These reports all indicated poor quality of the industrial effluent, citing high values for COD, BOD, suspended

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solids, total solids, color, turbidity, and nitrates, values for pH varied from extremely low to very high. No measurements for mercury were made except for an observation on 27 August 1969, when test results for the presence of mercury in an effluent sample were negative. In a memo to the NJDOH file in February 1969, the Metcalf and Eddy report was cited as reporting toxicity of the WRCC effluent due to the presence of mercury compounds (DOH-50). During April 1969, in response to a letter from NJDOH defining six parameters of the industrial effluent as unacceptable, WRCC advised NJDOH of methods which were being used and those planned in order to abate the wastewater problem (DOH-52).

2.5. Communications Between Wood-Ridge Chemical Corporation, the State of New Jersey, and Federal Agencies (1970)

During 1970, surveillance reports on the WRCC effluent were issued on 3 February, 13 April, and 25 August 1970 and noted a highly discolored effluent (DEP-8). Measurements for mercury in effluent samples collected on 3 February and 13 April 1970 yielded 0.03 and 0.015 ppm,¹ respectively. On 12 August 1970, representatives of the US Department of Interior, Federal Water Quality Administration, sampled effluent from WRCC and Berrys Creek, 100 yards downstream from the WRCC outfall, and found 1,500.0 and 17.0 ppb, respectively (1.5 and 0.017 ppm)(EPA-8).² Also during August 1970, the US Environmental Protection Agency (US-EPA) Operations Branch found the following results from collected samples (EPA-20):

<u>SAMPLE SOURCE</u>	<u>CONCENTRATION OF MERCURY</u>
Effluent, unfiltered	5,000 µg/l (= ppb)
Effluent, filtered =	1,600 µg/l
Berrys Creek, upstream of effluent, unfiltered	10 µg/l
Berrys Creek, downstream of effluent, unfiltered	210 µg/l
Sediment [Berrys Creek], upstream of effluent, dry weight	8,475 mg/kg (=ppm)
Sediment [Berrys Creek], downstream of effluent, dry weight	7,440 mg/kg

The effluent sample was an 8-hour composite sample at an estimated 35 gallon per minute flow. Using an average of 5.0 ppm and the estimated flow, approximately 2.1 lbs. of mercury was calculated to be discharged from the site per day.

On 8 October 1970, US-EPA sampled the WRCC effluent and found 9.2 ppm mercury (EPA-21). In October 1970, WRCC proposed a three phase in-house program to reduce what was estimated to be 4.2 lbs. of mercury per day (Federal Water Quality Administration (FWQA), 55 GPM x 24 hours x 7.0 ppm mercury content) to less than 0.5 lbs. per day (VE-4). Values of 7.0 and 1.4 ppm mercury were found in unfiltered and filtered, respectively, 24 hour composite samples of the WRCC effluent (EPA-22).

¹ Equal to 30 and 15 ppb, respectively.

² US-EPA was established during mid-1970 by Presidential Reorganization Plan Number 3. All responsibility and authority of FWQA were transferred to US-EPA at that time.

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During November 1970, a meeting was held between FWQA, WRCC, and NJ-DEP (including water quality aspects formerly administered by NJDOH)¹ representatives to discuss plans to reduce the mercury discharge to less than 0.1 lb. per day (DEP-1). Subsequent to the meeting, several WRCC inter-office memoranda explained test procedures and monitoring results of the industrial effluents (VE-5,6). WRCC inter-office memoranda during early 1971 acknowledged the lowering of the FWQA discharge standard of 0.5 lb. to 0.1 lb. per day on 1 July 1971 and indicated efforts planned to satisfy the standard (VE-8 through 11). Also during early 1971, inter-agency memoranda and letters between US-EPA and Ventron (WRCC) were written keeping all parties informed of plant processes, monitoring results, and progress obtained in treating the effluent (VE-12 through 16). On 10-11 February 1971, a 24-hour composite total plant effluent sample contained 4.95 ppm mercury (EPA-23). On 30 June 1971, an application for a discharge permit was made to the US Army Corps of Engineers (VE-17). During July and August 1971, several letters were exchanged between US-EPA and Ventron (WRCC) noting problems of monitoring the discharge, discrepancies in submitted data, and general notes on treatment procedures (VE-19 through 24). In a letter dated 27 September 1971 from US-EPA to Ventron (WRCC), an analysis of monitoring data of the WRCC effluent submitted to US-EPA showed that mercury levels in the treated effluent ranged from 0.05 to 0.95 lb/day with a median of 0.16 lb for 27 sampling days and a range of 0.10 to 3.70 lbs/day with a median of 0.40 lb in the total effluent (VE-26). It was concluded that additional mercury may be entering the effluent stream along its 1,000 foot route from the treatment facility to the point of discharge. This latter conclusion also was suggested at an on-site meeting between Ventron and US-EPA personnel on 16 September 1971 (VE-25). It was decided that a sampling program of soils and water would be conducted by US-EPA personnel. Samples collected on 26 October 1971 were found to contain the following concentrations of mercury (EPA-24):

<u>SAMPLE SOURCE</u>	<u>CONCENTRATION OF MERCURY (ppm)</u>
Effluent stream at Wier Basin entrance	0.860
Effluent stream at Wier Crest	0.820
Effluent stream at final discharge	0.970
On-site non-mercury bearing drain	0.060
Effluent from treatment system	0.240
Sediment from non-mercury pit (Bldg. 13A)	250
Final sludge from treatment	250

On 30 December 1971, eleven liquid samples and one sediment sample were collected on the Ventron site (EPA-25). Although exact locations for these samples now can not be determined, the concentration of mercury in the liquid samples ranges from 0.010 to 0.081 ppm, and a concentration of 230 ppm mercury was determined in the sediment sample.

In January 1972, an application for a discharge permit was resubmitted to the US Army Corps of Engineers by Ventron (VE-28). Also in January 1972, groundwater and soil samples from the Ventron site were collected and analyzed by Metcalf and Eddy, Inc., consulting engineers for Ventron (VE-29). Mercury concentrations in soil borings ranged from 5.0 to 375

¹ NJ-DEP was created by law during 1970. Responsibility and authority for water quality were transferred from NJ-DOH to NJ-DEP at that time.

ppm. Samples of groundwater which accumulated in the test holes after the rain sample pit, was found to contain concentrations from 5.5 to 11.00 ppm, unfiltered, and from 0.0 to 2.69 ppm of mercury, filtered. Throughout 1972 and at least until May 1973, the Ventron Corporation monitored its effluent daily for mercury and submitted data to NJ-DEP on a monthly basis (DEP-8). Additionally, surveillance reports of the Ventron effluent were made by NJ-DEP on 19 January and on 21 March 1973 (DEP-8). On 24 February 1972, Ventron was advised by NJ-DEP of high pH and oxygen demand in effluent samples collected in January 1972 (DEP-8). On 18 April 1973, NJ-DEP requested Ventron to correct conditions causing increased mercury discharges and unacceptable pH variations (pH 2.4 to 9.4) in the effluent as reported in the February operating report (VE-32). On 24 May 1973, an order was served on Ventron to cease violations against the Air Pollution Control Code as observed on 15 March 1973 by NJ-DEP inspectors (DEP-2).

In February 1973 an inter-office Ventron memorandum described mercury poisoning found in an employee at the Wood-Ridge plant (VE-31). The only other record of injury resulting from mercury was an accident report to the New Jersey Department of Labor and Industry regarding chemical burns to the right knee and thigh of an employee in July 1971 (DLI-1). In August 1973, preliminary terms for purchase of the Wood-Ridge property by Mr. Robert Wolf were proposed by Ventron (VE-34). In October 1973, NJ-DEP approved a reduced monitoring schedule proposed by Ventron (DEP-8).

2.6. Closure of the Wood-Ridge Plant and Sale of the Site, 1974

On 20 May 1974, Ventron notified NJ-DEP that the Wood-Ridge plant operations had ceased and that title to the property had changed hands (DEP-8). Surveillance reports of the Ventron property were made on 7 and 20 May 1974, and in a letter dated 29 May 1974, NJ-DEP directed Ventron to analyze and remove the danger of runoff from chemicals and wastes at the vacated property (VE-35). In 17 June 1974, Ventron responded claiming it was not required to comply with the directive since it no longer owned the property (DEP-8). On 9 May 1974, representatives of the New Jersey State Department of Labor inspected the Ventron site prior to its scheduled demolition in June 1974 (DLI-2). Recommendations were made for a more thorough clean-up of debris and precautionary measures to be taken by workmen during the demolition.

2.7. Events During the Demolition of the Buildings

Demolition of the buildings on site allegedly began during the first week of June 1974. On 7 June 1974, the discharge of chemicals from the site was observed during the demolition of the buildings as a result of the wetting of the demolition area. Personnel from the Hackensack Meadowlands Development Commission (HMDC), US-EPA, and NJ-DEP arrived on the site on 7 June 1974 and collected various samples of water, sediment, on-site liquids, and solid materials (EPA-5 through 8). Concentrations of mercury in water collected on the site ranged from 15.0 to 285.0 ppm (EPA-26). Water

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samples collected upstream and downstream from the Ventron site contained 0.22 and 14.0 ppm of mercury respectively. Samples of solid materials collected on the site ranged from 11.5 to 9,500 ppm mercury with one sample containing virtually pure mercury. Samples of sediment collected on the site and upstream from the site in Berrys Creek contained 17,700 and 9.9 ppm of mercury respectively (EPA-26). On 12 June 1974, a meeting was held between representatives of NJ-DEP, US-EPA, HMDC, Ventron, Ottolito Demolition Company (subcontractors), Rovic Construction Company (a subsidiary of Wolf), and GAESS Environmental Inc. (handlers of liquid wastes) (EPA-5). Agreements concerning the proper disposal of chemical wastes and contaminated soils with respect to a 10 June 1974 Order (DEP-3) from NJ-DEP to clean up and remove hazardous materials, were made at the meeting and summarized in a certified letter to Rovic Construction from NJ-DEP on 17 June 1974 (WV-2). Prior to the 7 June 1974 observation of the chemical waste discharge from the Ventron demolition site, an oil slick was discovered on Berrys Creek by members of the Bergen County Health Department and reported to HMDC on 3 June 1974. The oil slick was traced to the Ventron site, and the US Coast Guard initiated the clean-up (DEP-9). Rovic Construction was fined \$2,000 for the spill by the US Coast Guard (WV-12).

On 19 June 1974, NJ-DEP inspected the site and found that demolition was in progress, contrary to the agreement of 12 June 1974. Also, a broken water line on the property was releasing water, which then was discharging into the former wastewater system. Rovic Construction and Ottolito Demolition were advised that they were in violation of the 12 June 1974 agreement (DEP-9). On 20 June 1974, NJ-DEP and US-EPA representatives inspected the site and found demolition had ceased (DEP-9). Water samples collected from the plant sewer system and from Berrys Creek, upstream and downstream from the Ventron site on 21 June 1974, contained 0.140, 0.011, and 0.0039 ppm, respectively (EPA-27). A site inspection on 27 June 1974 by NJ-DEP found no demolition in progress; however, a sample of the effluent from the site into Berrys Creek contained 28.0 ppm of mercury (EPA-28). On 2 July 1974, the US Testing Company Inc. (USTC) advised NJ-DEP that it had been retained by Rovic Construction to collect and analyze runoff water from the demolition site (DEP-4). Several liquid waste handlers were contacted by Rovic Construction, and cost estimates for the removal of waste on the site were requested. On 11 July 1974, a soil core from the property was taken by EPA personnel to a depth of 3 feet. Droplets of mercury were found in samples from the soil surface and at depths of one and two feet below the surface. Concentrations up to 200,000 ppm of mercury were observed in the samples (EPA-30). Additionally, high concentrations of cadmium, lead, zinc, chromium, nickel, and arsenic were found in the samples. After a notice of violations was issued to Rovic Construction by US-EPA on 21 June 1974, meetings were held on 1 July and 16 August 1974 between representatives of NJ-DEP, US-EPA, and Rovic Construction (DEP-9). On 16 August an agreement of understanding was entered into by Rovic Construction, NJ-DEP, and US-EPA, which provided for terms of construction of Building #1 on the western most section of the site (EPA-10). Additional tests for mercury on soil borings at various locations on the eastern section of the site were required. During late summer and autumn of 1974, the soil borings and analyses for mercury conducted on the eastern section of the site were completed

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(WV-15 through 19). Alternatives for extraction of mercury from contaminated soil were explored as was the feasibility of removing the contaminated soils (WV-26 through 33). In February 1975, a proposal for specific requirements to be met during and after construction of Building #2 on the eastern section of the site was submitted to Rovic Construction by US-EPA after an initial plan was proposed to US-EPA on 30 January 1975 (EPA-11). The initial plan was based on soil borings and analyses and on the negative results of feasibility studies for the extraction of mercury from contaminated soils or the complete removal of the soils. On 4 April 1975, US-EPA sent a letter to Rovic Construction outlining a basis for agreement, stipulating that a formal agreement would be required (DEP-9). On 5 August 1975, Rovic Construction notified NJ-DEP that construction was proceeding on the site for Building #2 (DEP-9). NJ-DEP advised Rovic verbally and by mail on the same day that no agreement had been made for construction of Building #2. On 8 August 1975, NJ-DEP sent Rovic Construction a telegram order to cease removal and relocation of soil on the site and to seal all removed and stockpiled materials (DEP-7). On 11 August 1975, NJ-DEP and US-EPA representatives inspected the site and found topsoil being scraped contrary to the telegram order of NJ-DEP (DEP-9). A meeting was held on 22 August 1975 between US-EPA, NJ-DEP, Rovic Construction, and Wolf Enterprises during which Mr. Wolf criticized the delay of construction and subsequently was reminded that no formal agreement had been made. During September 1975 a draft agreement was circulated for review. On 17 October 1975, Rovic Construction Company and attorneys met with US-EPA personnel and on 11 November 1975, NJ-DEP referred the case to the Attorney General (DEP-9).

During late 1974 and 1975, samples of water and sediments on and off the site were collected during various inspections of the site by personnel from NJ-DEP and US-EPA. A summary of data from samples collected during this period through 1976 is presented below:

DATE	SOURCE	MERCURY CONCENTRATIONS (ppm)
19 September 1974 (EPA-32)	Water-runoff ditch	15.8
	Berrys Creek water, upstream	0.001
	Berrys Creek water, downstream	0.940
13 September 1974 (EPA-31)	Sediment-abandoned lagoon on-site	1.2
14 February 1975 (DEP-10)	Water, Ventron discharge	0.013
	Sediment, Ventron discharge	165.0
	Water, 150 ft. below discharge	0.300
	Sediment, 150 ft. below discharge	167.0
	Water-flood tide at tide gate, West Riser	0.0
	Sediment, flood tide at tide gate, West Riser	147.0

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DATE	SOURCE	MERCURY CONCENTRATIONS (ppm)	
5 November 1975 (EPA-35)	Sediment, 1.2 miles upstream from Ventron site (1)	25.0	
	Sediment, West Riser tide gate (2)	35.0	
	Sediment, 0.2 mile downstream from Ventron site (3)	0.3	
	Water, (No. 1)	0.6 ppb	
	Water, (No. 2)	0.4 ppb	
	Water, (No. 3)	0.3 ppb	
	Cattail-tuber and top (No. 2)	0.3	
	Phragmites - stem (No. 2)	1.2	
	Phragmites - tuber and top (No. 3)	1.5	
	Phragmites - stem (No. 3)	1.1	
	24 August 1976 (EPA-36)	Sediment (No. 2)	577
		Sediment (No. 3)	4,480
Sediment (No. 1)		5.5	
Water (No. 1)		0.20 ppb	
Water (No. 2)		2.1 ppb	
Water (No. 3)		0.43 ppb	
Phragmites - tuber (No. 1)		*	
Phragmites - stem (No. 1)		*	
Whole killifish (No. 1)		*	
Cattail - tuber (No. 3)		51.0	
Cattail - stem (No. 3)		1.2	
Phragmites - tuber (No. 3)		170.0	
Phragmites - stem (No. 3)		3.5	
12 May 1976 (DEP-11)	Soil - Ventron site, surface	3.3 to 5.6	
	Soil - Ventron site, 7 inches below	4.2	
	Soil - Ventron site, 10 inches below	5.2	
	Soil - Ventron site, 11 inches below	4.3	
	Soil - Ventron site, 12 inches below	4.2	
	Soil - Ventron site, 17 inches below	4.8 to 5.2	

* Not available.

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1. METHODS EMPLOYED IN THIS INVESTIGATION

3.1. Details of Locations

The locations of observation wells and of stations from which samples of water, soil, and/or sediments were collected are indicated on Figure 2.

3.1.1. Observation Wells

Samples of groundwater were collected from ten wells on the Subject Site. Eight of these wells are designated by alphanumeric symbols (W1 through W8) on Figure 2. The other wells are designated WE (east well) and WS (south well). An eleventh well is located inside of the building on the Wolf Realty property, but no samples were drawn from it during this investigation.

3.1.2. Stations for Collections of Surface Water and Sediments

Samples of water were collected from nine stations on or adjacent to the Subject Site. Samples of sediments were collected from the channels at the seven stations in which the channel was founded in soil and not paved. The approximate locations of the stations are indicated by small, colored squares and the numbers 1 through 9 on Figure 2.

Station 1 and Station 2 are located in an asphalt-covered swale situated between the two large buildings on the Subject Site. Two stations are located in an unlined ditch. This ditch is oriented northwest/southeast, and it is situated approximately 20 feet to the southwest of the two large buildings. The paved swale is located to the north of this ditch; it is oriented approximately perpendicular to the ditch; and it discharges into the ditch. Station 3 is located to the northwest of the confluence of the swale with the ditch, and Station 4 is located to the southeast of that confluence.

Another unlined ditch extends toward the southwest from its junction with the ditch in which Stations 3 and 4 are located. Station 5 was situated in this ditch.

Station 6 is located in an area that is labelled "open ditch" on Figure 2. A culvert at the northwest end of this ditch extends below the soil surface and is oriented toward the west. Another culvert, at the southeast end of the ditch, extends toward the southeast and emerges at Berrys Creek at a point that is labelled "drain discharge" on Figure 2. Station 7 is at the mouth of the reinforced concrete pipe, or culvert.

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Two stations are located in Berrys Creek. Station 8 is approximately 230 feet upstream from the drain discharge. It is near the left (east) bank of Berrys Creek, and is north of a railroad trestle. Station 9 is approximately 140 feet downstream from the drain discharge. It is south of the West Riser Ditch tide gate (not functional), and near the right (west) bank of Berrys Creek.

3.1.3. Stations for Collections of Soil

The locations of areas from which samples of soil were obtained are indicated by colored circles on Figures 1 and 2. Each station is identified with a unique alphanumeric symbol (1S through 23S). Variations in the sizes of the circles on Figure 2 are intended to depict the approximate areas in which subsamples were collected. Station 23S, which is located about 30 feet to the southeast of the Wolf Realty building, is marked by a dark line. Subsamples were collected from the linear area indicated.

3.2. Field Methodology

The procedures that were utilized to select sites and to collect samples are described in the following paragraphs.

3.2.1. Collections of Soil

Samples of soil were collected in two ways. During the installation of eight of the observation wells (W1 through W8), materials were collected in 2-foot long sections, or cores, sequentially from the surface to the bottom of the well hole. The holes were drilled during the period from 24 through 26 May 1977 by Mr. Lou Ontek, Diamond Drilling Company, Inc., Jackson, New Jersey. Personnel of Jack McCormick & Associates, Inc., observed the operations, split each core lengthwise into two approximately equal parts, removed one half of each sample from the split spoon drill, and logged and bagged the sample.

A second method was used to obtain samples of soil from Stations 1S through 23S. Before work began, points at which soil samples were to be obtained were plotted on a map of the site. Stations that are not located on the main section of the Subject Site were selected on the basis of their geographic relation to the Site -- generally to the north, south, east, and west -- and on the basis of exposure, or lack of pavement and structures, and accessibility.

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Stations were located on the Subject Site by drawing arcs with radii of 250 feet, 500 feet, 750 feet, 1,000 feet, and 1,250 feet from the center of the building on the Wolf Realty property. Points then were designated at approximately equal distances along each arc. Owing to problems of visibility as a result of the presence of tall, dense vegetation in places, the actual locations of several points were unintentionally offset in the field. The actual locations of the stations are indicated on Figure 2. Observation wells that were located on or near the plotted arcs were considered to provide adequate samples of the soil, and no duplicate station was placed near them. The stations on the 250-foot arc are: 11S, W6, and W7. Those on the 500-foot arc are: 10S, 13S, 12S, and 9S. Those on the 750-foot arc are: 8S, 14S, 15S, and W2. Those on the 1,000-foot arc are: W4, 16S, and 17S. Only Station 18S is on the 1,250-foot arc. Station 7S and Station 19S were added at the request of personnel from the Department of Environmental Protection.

In the field, personnel of Jack McCormick & Associates, Inc., located on the ground the positions indicated by points drawn on the aerial photographs. At each of these positions, a sample of soil was obtained. The position then was used as a center point, and additional samples were collected at distances of 5 meters to the north, south, east, and west from the center point. In total, samples of soil were collected from five places at each station.

At Station 23S, the pattern of sampling was modified to obtain samples from the area near a concrete cutoff wall. Samples from this station were collected at intervals of 5 meters along a line that was parallel to the cutoff wall and about 2 feet to the southeast of the cutoff wall.

At Stations 1S through 23S, the samples were collected with a manually operated bucket auger. Where large pieces of rock, concrete, glass, or other hard substances were encountered, a spade was used to excavate a small pit. Samples then were obtained from the wall of the pit.

Soil material was collected from 6-inch increments below the surface. The first increment was composed of material from the surface to a depth of 6 inches. The second increment was composed of materials from a depth of 6 inches to a depth of 12 inches below the surface, and so on. Only two vertical increments were collected at Stations 1S through 6S and at Stations 21S and 22S. At the other stations, four increments were collected (0-6, 6-12, 12-18, and 18-24 inches below the surface).

The soil from each vertical increment at each of the five places at a particular station was placed in a separate container and labelled. Enough material was taken from the soil auger to fill a small, plastic twistpack bag. The labelled samples were placed on ice for transportation to the laboratory.

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3.3.2. Samples of Groundwater

Wells W1 through W8 extend to depths of approximately 15 to 20 feet, and each is cased with 2-inch diameter PVC (polyvinyl chloride) pipe. The elevation of each well, at the collar, or uppermost part, and at the surface of the ground, was determined by Mr. Sabetay Behar, a registered land surveyor with offices in East Rutherford, New Jersey (Table 3).

At the time of installation, from 24 to 26 May 1977, wells W1 through W8 were pumped by the driller to remove sediments. Samples of water were obtained from these eight wells on 2 June, 8 June, and 13 July 1977 by personnel of Jack McCormick & Associates, Inc. On 8 June and 13 July 1977, samples also were obtained by these personnel from wells WE and WS that had been installed earlier.

Samples of water were drawn from the wells with a peristaltic pump. Each well was fitted with previously unused polyethylene tubing. All tubing was flushed with well water before collecting the sample to avoid any transfer of water or sediment from one well to another.

On 2 June 1977, samples were drawn from two levels in each well: 1 to 1.5 foot below the water surface and at a point 1 foot above the bottom of the casing. On 8 June and on 13 July 1977, one sample was drawn at the time of each collection, and the sample was drawn from a point about 1 foot below the surface of the water. The level of the water in each well was determined at the time of sampling by inserting a drop light into the casing. When electrodes at the tip of the drop light enter the water, a contact is established between them, and an electric current illuminates the bulb. The depth to the surface of the water then is read from the calibrated tape used to suspend the drop light.

The samples collected on 2 June 1977 were drawn between 0800 and 1035 hours, and were taken without reference to the level of the water in Berrys Creek. On 8 June and 13 July 1977, the wells were sampled during times that corresponded to periods near low water and near high water in Berrys Creek.

Samples of water were pumped into new polyethylene jars. Concentrated nitric acid immediately was added to the water as a preservative during the collections on 2 June and 8 June 1977. On 13 July 1977, the water was filtered with a 0.45 micron Millipore filter before the preservative was added. The jars then were returned to the laboratory.

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Table 3. Measurements of the depth of drilling and the absolute elevations at the ground and at the collar at the observation wells. No measurements of depth are available for wells WE and WS or for the well inside of the building on the Wolf Realty property.

Well No.	Drilling Depth (ft.)	Ground Elevation ^a	Collar Elevation ^a
W1	18	5.40	7.52
W2	24	11.00	11.64
W3	16	9.15	8.80
W4	18	9.77	10.23
W5	16	10.19	10.37
W6	16	5.39	6.34
W7	10	7.07	7.55
W8	16	7.17	7.67
WE	NA	4.40	6.35
WS	NA	4.60	7.68
(Inside building)	NA	8.18	7.97

^a Feet above mean sea level.

NA means Not Available

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2.3. Samples of Surface Water

Stations from which samples of water were to be collected were established at points along the system of exposed swales and ditches through which stormwater drains from the Subject Site. Stations 1 and 2 are in a paved swale that discharges to an open ditch in which Stations 3 and 4 are located. Station 5 is in an open ditch that joins the station 3/4 ditch near the mouth of a culvert that is located to the southeast of the building on the Wolf Realty property.

Station 6 is located at the northeast end of the culvert that extends from near Stations 4 and 5. Station 6 also is at the northwest end of an open ditch. Approximately 50 feet to the southeast of Station 6, the open ditch ends, and the mouth of a second culvert is exposed. This second culvert ends at the bank of Berrys Creek, about 640 feet to the southeast. Station 7 was placed at the southeast end of the culvert, at a point near where water from the site enters Berrys Creek. Stations 8 and 9 are located in Berrys Creek at points upstream and downstream, respectively, from the discharge point.

Samples of water were collected hourly during a 12-hour tidal cycle at Station 6 on 19 May 1977. Samples were collected from all nine stations on 8 June 1977. At Station 1, a sample was collected from an isolated pool at 0940 hours and from a sump beneath a grill-covered storm sewer cover at two other times. Samples were taken from a ponded area at Station 5 at three times. Collections were made at Stations 2 through 4 and Stations 6 through 9 at intervals of approximately 1 hour throughout a tidal cycle, from one period of low water to the next period of low water in Berrys Creek (or the West Riser Ditch). Measurements of the level of the water in Berrys Creek at intervals of approximately 1 hour on 8 June 1977 are exhibited in Table 4.

On 13 July 1977, samples of water were collected from Station 7, at the discharge point, and Stations 8 and 9 in Berrys Creek. Four samples were collected at each station between the hours of 0805 and 1400.

Each sample was obtained by placing a previously unused, 250 ml polyethelene bottle into the water in a position that was slightly off of horizontal. The mouth was elevated to permit water to enter the bottle. After the collection was made, concentrated nitric acid was added to the water as a preservative. The samples then were returned to the laboratory.

Table 4 Measurements of the levels of the water in Berry's Creek at a temporary staff gage attached to a piling near Station 7 on 8 June 1977.

Measurement Time (EST)	Staff Gage Reading ^a (feet)
0950	0.32
1030	1.12
1130	2.38
1230	4.36
1335	4.40
1430	4.68
1530	4.56
1630	3.90
1730	3.77
1835	1.53
1945	0.19
2045	-0.30
2145	0.00

^a Measurements are relative indications of the rise and fall of the water surface from one period of low water to the next period of low water. The staff gage was not calibrated to sea level.

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3.2.4. Samples of Sediments

Samples of sediments were collected from the channels of the ditches at Stations 2 through 6 and from the channel of Berrys Creek at Stations 7 through 9 on 27 June 1977. One core of sediments was obtained at each station by driving a Schedule 40 PVC pipe (2 inches inside diameter) into the channel bottom to a depth of approximately 24 inches. After the tube was removed from the channel, paper toweling was wadded into the ends to hold the sample, the tube was sealed in a plastic bag, and the bag was labelled. The tubes immediately were placed on ice for delivery to the laboratory.

3.2.5. Proof of Connection Between Stations 4 and 6

Visual inspections suggested that water from the ditch at Station 4 flows through a buried culvert to Station 6. To determine if this conclusion was correct, red food coloring was added to the water at Station 4 at 1300 hours on 19 May 1977. The water at Station 6 was examined for traces of the dye at the times of regularly scheduled collections.

3.3. Laboratory Methodology

The procedures that were utilized in the laboratories of Jack McCormick & Associates, Inc., to handle, prepare, and analyze samples of water, soil, and sediments collected during this investigation are described in the following paragraphs. The methods used for the digestion of samples of soil and sediments, and of the methods used for elemental analyses, are those of the US-EPA (United States Environmental Protection Agency). The methods are described in Methods for Chemical Analysis of Water and Wastes, published by the US-EPA during 1974, and in Standard Methods for the Examination of Water and Wastewater, Edition 14, published by the American Public Health Association and others during 1976.

3.3.1. Determinations of Mercury

The concentrations of mercury in all samples were determined by the cold vapor mercury method. Samples of soil and sediments were digested before analysis. For each determination, a 100 ml aliquot of the sample was used. Samples were diluted with distilled water when necessary. All dilutions were made with new glass pipettes that were used once and then discarded.

3.3.2. Determination of Arsenic

The concentrations of arsenic in all samples were determined by the silver diethyldithiocarbamate method.

3.3.3. Determination of Other Metals

The concentrations of cadmium, lead, nickel, and zinc in all samples of soil and sediments were determined by the standard US-EPA flame atomic absorption methods. Most of the samples of water also were processed by these methods. Selected samples of water were

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analyzed by the flameless atomic absorption system (graphite furnace) in order to obtain a higher sensitivity for lead and cadmium analyses. This technique is described in Analytical Methods for Atomic Absorption Spectrophotometry Using the HGS Graphite Furnace, published by the Perkin-Elmer Corporation of Norwalk, Connecticut, during 1977.

3.3.4. Samples of Soil

Upon receipt, the samples of soil were removed from the ice and placed under refrigeration. To prepare the materials for analysis, the five samples from the same vertical increment at a particular station were composited. This was done by emptying the soil from the five original bags into a large, previously unused plastic bag. The soil then was mixed by kneading and shaking the bag.

After a combined sample was mixed thoroughly, approximately 10 g of soil were withdrawn, placed in a previously unused petri dish, and allowed to dry for about 16 hours at a temperature of 60°C. The dry sample then was placed in a mortar and ground with a pestle. The mortars and pestles were cleaned thoroughly with nitric acid before each use.

For the analysis of mercury, the soils were digested by the US-EPA alternate procedure that employs an autoclave. Samples for the analysis of arsenic were concentrated and digested by procedures described under Standard Method 104b. Samples for the analysis of cadmium, lead, nickel, and zinc were prepared by the technique prescribed by US-EPA for the determination of total metals.

3.3.5. Samples of Water

Samples of water were prepared for analysis by procedures described by the US-EPA for the determination of the concentrations of metals. Samples to be analyzed for arsenic were mixed with sulfuric acid and boiled until fumes of sulphur trioxide formed. Distilled water and sulfuric acid then were added, and the sample was boiled again. This technique removes nitric acid and organic material which could cause errors in the analysis.

3.3.6. Samples of Sediments

Upon receipt, the samples of sediments were removed from the ice and placed under refrigeration. To prepare the materials for analysis, each sediment core was divided into 3-inch long increments. Although the cores were driven to a depth of 24 inches in the field, the lengths of the retrieved samples were less than or equal to 12 inches. That the samples were less than 24 inches in length may be attributed to sediment compaction and a partial loss of sample from the end of the tube upon removal from the channel. Samples less than 12 inches in length were obtained from Stations 3 and 4. The sample from Station 4 was divided into only three increments so that the increment length of 3 inches could be used and so that a consistency of increment length would be maintained with other samples.

The materials in each increment were mixed thoroughly. A sample of 10 g then was placed in a disposable petri dish and dried for approximately 16 hours at a temperature of 60°C. The sample was ground in a mortar with a pestle. The mortars and pestles were cleaned with nitric acid before each use. The sample then was split for analysis. The aliquots were treated in the same manner as samples of soil to digest them.

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4. RESULTS

This section is intended to present an unbiased narrative description of the results of the analyses for mercury and other metals in samples of soil, groundwater, sediments, and surface water collected on or near the Subject Site. The analytical results are compiled in Tables 5 through 13. The variations in the concentration of mercury at Station 6 during a 12-hour period is illustrated graphically in Figure 3. The variations in the concentration of mercury at Stations 7, 8, and 9 during 2 periods of 12 and 6 hours are illustrated graphically in Figures 4 and 5.

4.1. Results of Analyses for Mercury (Hg)

4.1.1. Mercury in the Soil

Concentrations of mercury in samples of soil obtained during the installation of seven wells on the Subject Site (W1 through W7) ranged from 0.7 ppm to 2,592 ppm (Table 5). The highest concentrations of mercury (1.080 ppm to 2,592 ppm at 0 through 6 feet in depth) were observed in samples from Station W6. Concentrations in excess of 100 ppm were observed in at least two 2-foot increments in samples from five of the other six stations.

Table 5 also includes the results of analyses of soil samples from Station W8, which is located in the eastern quadrant of the intersection between Park Place East and Ethel Boulevard (Figure 2). The concentrations of mercury in these samples ranged from 0.7 ppm, at a depth from 8 to 10 feet, to 432 ppm, at a depth of 0 to 2 feet.

The results of tests on samples of soil from 23 stations (1S through 23S) are displayed in Table 6. In samples from sixteen stations on the Subject Site (Stations 4S, 7S through 19S, 21S, and 23S), the concentrations of mercury in the various 6-inch increments ranged from 3.9 ppm (6 to 12 inches at Station 18S) to 123,000 ppm (18 to 24 inches at Station 14S). The highest concentrations in the upper three increments (0 to 18 inches in depth) consistently were observed at Station 23S. In the interval from 18 to 24 inches, the concentration of mercury at Station 23S was 4,719 ppm. This was surpassed only by the observation at Station 14S.

Seven series of samples were obtained for soil at seven stations around the subject site (Stations 1S, 2S, 3S, 5S, 6S, 20S, and 22S). The concentrations in samples of soil from five upland sites (Stations 1S, 2S, 3S, 5S, and 6S) ranged from 1.5 ppm to 6.4 ppm from 0 to 6 inches in depth, and from 1.9 ppm to 18.5 ppm at depths from 6 to 12 inches (Table 6). At a sixth upland site (Station 20S), which is located about 150 feet northeast of Ethel Boulevard, the concentrations of mercury ranged from 75 ppm near the surface (0 to 6 inches) to 15.1 ppm at a depth of 18 to 24 inches.

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Table 5. Concentrations of mercury, arsenic, lead, nickel, zinc, and cadmium levels in samples of soil from wells (concluded).

Well No.	Date	Depth (ft)	Hg	As	Pb	Ni	Zn	Cd
W7	26 May 1977	0-2	193	20	190	11	170	1
		2-4	234	16	170	12	240	1
		4-6	83	4	81	16	120	2
		6-8	58	7	85	11	100	1
		8-10	1.8	4	12	17	47	0.3
W8	26 May 1977	0-2	432	5	81	14	280	0.9
		2-4	105	5	110	14	190	0.9
		4-6	1.9	<0.5	11	8	110	0.3
		8-10 ^a	0.7	2	7	10	27	<0.3
		10-12	1.2	1	5	7	19	<0.3
		12-14	1.3	1	7	11	24	0.3

^aAt the direction of personnel from the Department of Environmental Protection, samples from intervening depths were collected, but were not analyzed.

^bIn Well W4, no material was recovered from depths between 4 and 8 feet. A fragment of wood was recovered from 8 to 10 feet.

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Table 6. Concentrations of mercury, lead, nickel, zinc, and cadmium in samples of soil collected at stations 1S through 23S during the period from 15 through 21 June 1968 (all data are mg/kg, or ppm, dry weight basis).

Station No.	Depth (in.)	Hg	Pb	Ni	Zn	Cd	
1S	0-6	4.8	6	92	7.8	59	1.4
	6-12	1.9	11	5,710	16.4	118	1.3
2S	0-6	6.4	8	184	20	121	2.1
	6-12	3.5	6	116	13	95	1.3
3S	0-6	6.1	6	40	26	42	1.7
	6-12	2.6	10	40	30	56	1.5
4S	0-6	619	58	321	86	28,832	78
	6-12	746	64	111	95	25,208	72
5S	0-6	2.4	20	512	23	426	4.2
	6-12	18.5	14	287	20	284	3.6
6S	0-6	1.5	18	433	13	180	2.0
	6-12	2.0	11	594	41	267	3.6
7S	0-6	15.4	5	737	65	882	19
	6-12	4.7	10	583	65	795	5.2
	12-18	7.1	11	578	100	1,026	13
	18-24	3.9	7	550	120	521	5.5
8S	0-6	58	5	479	52	1,183	3.9
	6-12	117	14	184	49	315	2.3
	12-18	61	11	885	45	860	33
	18-24	850	13	671	40	1,391	14
9S	0-6	30	5	44	29	13,454	1.7
	6-12	23	6	117	80	480	3.3
	12-18	13.8	7	88	27	405	2.6
	18-24	8.4	7	198	26	1,254	3.7
10S	0-6	46	15	1,225	80	1,100	6.7
	6-12	8.6	10	11	51	553	3.8
	12-18	10.0	12	749	66	608	9.1
	18-24	13.7	18	2,071	62	586	6.4
11S	0-6	25	6	913	135	488	4.0
	6-12	14.1	6	462	33	316	2.8
	12-18	19.5	5	1,089	42	475	3.8
	18-24	32	6	423	164	408	27

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Table 6. Concentrations of mercury, arsenic, lead, nickel and cadmium levels in composite soil samples from stations 12S, 13S, 14S, 15S, 16S, 17S, 18S and 19S (continued).

Station No.	Depth (in.)	Hg	As	Pb	Ni	Zn	Cd
12S	0-6	22	7	132	41	550	3.5
	6-12	25	11	899	77	1,320	7.9
	12-18	43	10	312	135	2,065	8.4
	18-24	116	13	614	240	2,772	86
13S	0-6	151	5	3,518	52	1,800	8.3
	6-12	2,008	14	3,926	35	1,979	9.3
	12-18	1,294	16	2,629	58	1,998	18
	18-24	654	14	2,166	158	3,139	10
14S	0-6	221	6	270	49	17,510	7.6
	6-12	276	6	196	45	6,866	4.7
	12-18	63	9	502	65	3,437	3.6
	18-24	123,000	11	322	91	4,584	6.9
15S	0-6	5.7	9	79	38	115	3.1
	6-12	5.5	6	215	35	180	1.8
	12-18	6.8	8	490	95	405	3.7
	18-24	9.8	11	388	37	294	3.1
16S	0-6	20.2	19	672	195	4,719	18
	6-12	26	30	896	157	3,392	15
	12-18	39	21	970	216	4,382	12
	18-24	23	22	990	132	3,770	13
17S	0-6	11.1	29	844	130	1,053	3.3
	6-12	11.9	9	670	49	715	5.5
	12-18	14.8	9	2,717	78	965	8.7
	18-24	12.9	11	964	85	1,204	9.2
18S	0-6	9.2	7	354	37	564	4.8
	6-12	3.9	7	298	37	4,491	29
	12-18	5.2	5	214	32	362	8.9
	18-24	19.9	9	385	45	711	8.4
19S	0-6	23	4	257	213	535	4.9
	6-12	18.4	1	164	19	313	2.6
	12-18	197	7	1,314	44	6,725	2.6
	18-24	328	12	580	33	13,634	6.0

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Table 6. Concentrations of mercury, arsenic, lead, nickel, zinc, and cadmium levels in composite soil samples from stations 1S through 23S (concluded).

Station No.	Depth (in.)	Hg	As	Pb	Ni	Zn	Cd
20S	0-6	75	6	123	21	112	1.8
	6-12	34	6	216	21	122	1.9
	12-18	19.4	4	362	26	183	2.2
	18-24	15.1	7	395	19	202	2.2
21S	0-6	546	49	390	103	15,051	43
	6-12	1,444	82	125	21	502	7.5
22S	0-6	367	45	430	211	4,286	31
	6-12	1,185	148	396	289	10,670	71
23S	0-6	2,558	6	117	58	1,573	2.7
	6-12	2,885	7	179	58	2,032	3.7
	12-18	3,397	8	190	55	12,372	4.0
	18-24	4,719	8	344	27	818	2.2

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Table 7. Concentrations of mercury, arsenic, lead, nickel, zinc, and cadmium in unfiltered samples of water collected from wells W1 through W8 on 2 June 1977. Units are $\mu\text{g/l}$, or ppb.

Well No.	Collection Time (EST)	Collection Level	Hg	As	Pb	Ni	Zn	Cd
W1	0800	T	0.7	<10	<500	<200	100	<50
	0800	B	1.0	<10	<500	<200	170	<50
W2	0900	T	3.0	<10	<500	<200	110	<50
	0900	B	84	15	<500	<200	22,400	<50
W3	0930	T	1.2	<10	<500	<200	60	<50
	0930	B	5.1	11	<500	<200	150	<50
W4	0945	T	0.4	<10	<500	<200	30	<50
	0945	B	2.7	<10	<500	<200	160	<50
W5	1000	T	1,110	12	1,000	<200	21,300	<50
	1000	B	3,770	31	3,000	<200	25,200	<50
W6	1010	T	198	<10	<500	<200	240	<50
	1010	B	74	<10	<500	<200	150	<50
W7	1020	T	210	<10	<500	<200	250	<50
	1020	B	194	10	<500	<200	380	<50
W8	1035	T	0.7	<10	<500	<200	90	<50
	1035	B	9.3	<10	<500	<200	280	<50

T = 1 to 1.5 feet below the surface of the water

B = 1 foot above bottom of casing

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The seventh station in Berrys Creek (Station 228) was located on a peninsula of marsh soil that is enclosed by a meander of Berrys Creek (Figure 2). The concentrations of mercury in the samples from this site were 367 ppm (0 to 6 inches) and 1,100 ppm (6 to 12 inches).

4.1.2. Mercury in Groundwater

The results of analyses of samples of water from wells are presented in Tables 7 through 9. The concentrations of mercury detected in unfiltered samples collected on 2 June 1977 (Table 7) ranged from 0.4 ppb to 3,770 ppb and those in unfiltered samples obtained on 8 June 1977 (Table 8) ranged from <0.1 ppb to 1,077 ppb. Samples that were collected on 13 July 1977 (Table 9) were filtered before preservation and analysis. No mercury was detectable in the filtered samples from seven of the nine wells on the Subject Site (W1 through W7) or in the well adjacent to Park Place East (W8). The concentrations of mercury in the South Well (WS) were 0.9 ppb, at the time of high water in Berrys Creek, and 0.8 ppb, at the time of low water. In the East Well (WE), the concentrations of mercury were 8.8 ppb and 4.3 ppb at the times of high and low water.

4.1.3. Mercury in Channel Sediments

The results of analyses of sediments are displayed in Table 10. At three stations located in a ditch that is known to discharge through the culvert at Station 7, the concentrations of mercury in the surficial sediments ranged from 81 ppm (6 to 9 inches) to 882 ppm (0 to 3 inches) at Station 3; from 179 ppm (6 to 9 inches) to 679 ppm (0 to 3 inches) at Station 4; and from 624 ppm (6 to 9 inches) to 361 ppm (0 to 3 inches) at Station 6.

At the outfall point (Station 7), analyses of samples from the channel of Berrys Creek adjacent to the mouth of the culvert revealed concentrations of mercury that range from 2,825 ppm near the surface to 89,162 ppm at a depth of 6 to 9 inches (Table 10). In Berrys Creek upstream from the discharge point (Station 8), the concentrations of mercury in the sediments range from 993 ppm near the surface to 14.7 ppm at a depth from 9 to 12 inches. At Station 9, which is on Berrys Creek downstream from the discharge point, the concentrations of mercury range from 5.6 ppm, at 6 to 9 inches in depth, to 57 ppm, near the surface.

The sediments at Station 5 contain mercury in concentrations that range from 1.2 ppm, at a depth from 9 to 12 inches, to 23 ppm, at a depth of from 3 to 6 inches (Table 10). It is presumed that water flows from Station 5 to Station 6, but no movement was observed during inspections.

4.1.4. Mercury in Surface Water

The results of analyses of samples of water from swales, ditches, and culverts on the Subject Site and from Berrys Creek are presented in Tables 11 through 13. Selected data for mercury also are displayed graphically in Figures 3 through 5.

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Table 8. Concentrations of mercury, arsenic, lead, nickel, zinc, and cadmium in unfiltered samples of water collected from wells W1 through W8, the east well, and the south well at times corresponding to periods of high and low water in Berrys Creek on 8 June 1977 (units are $\mu\text{g/l}$, or ppb).

Well No.	Collection Time (EST)	Tide Stage	Groundwater Level *	Hg	As	Pb	Ni	Zn	Cd
W1	1052	L	3.72	0.3	<10	<500	<200	80	<50
	1640	H	3.74	0.3	<10	<500	<200	80	<50
W2	1101	L	2.99	0.9	<10	<500	<200	50	<50
	1645	H	3.09	1.0	<10	<500	<200	40	<50
W3	1114	L	3.10	0.9	<10	<500	<200	60	<50
	1658	H	2.30	0.8	<10	<500	<200	40	<50
W4	1040	L	2.63	0.5	<10	<500	<200	40	<50
	1633	H	2.69	<0.1	<10	<500	<200	20	<50
W5	1148	L	2.27	1,077	26	1,400	<200	11,200	<50
	1628	H	2.19	68	10	<500	<200	2,800	<50
W6	1002	L	2.23	57	<10	<500	<200	70	<50
	1616	H	2.16	23	<10	<500	<200	30	<50
W7	0924	L	2.13	147	<10	<500	<200	190	<50
	1553	H	2.11	33	11	<500	<200	180	<50
W8	0912	L	1.87	1.6	<10	<500	<200	50	<50
	1541	H	1.85	0.5	<10	<500	<200	40	<50
WE	0937	L	1.72	41	78	<500	<200	50	<50
	1609	H	1.89	16.2	66	<500	<200	20	<50
WS	1014	L	1.80	35	18	<500	<200	4,500	<50
	1620	H	1.99	7.8	<10	<500	<200	3,400	<50

* Feet above mean sea level.

H = High water

L = Low water

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Table 9. Concentrations of mercury, arsenic, lead, nickel, zinc, and cadmium in filtered samples of water collected from wells W1 through W8, the east well, and the south well at times corresponding to periods of high and low water in Berrys Creek on 13 July 1977 (units are $\mu\text{g/l}$, or ppb).

Well No.	Collection Time (EST)	Tide Stage	Groundwater Level *	Hg	As	Pb	Ni	Zn	Cd
W1	0700	H	2.72	< 0.3	<20	<10	<100	160	<3
	1242	L	2.72	< 0.3	<20	<10	<100	150	<3
W2	0750	H	2.44	< 0.3	<20	<10	<100	110	<3
	1301	L	2.94	< 0.3	<20	<10	<100	100	<3
W3	0900	H	2.35	< 0.3	<20	<10	<100	140	<3
	1310	L	2.43	< 0.3	<20	<10	<100	40	<3
W4	0907	H	2.68	< 0.3	<20	<10	<100	40	<3
	1320	L	2.89	< 0.3	<20	<10	<100	20	<3
W5	0915	H	1.87	< 0.3	<20	<10	<100	10	6.8
	1329	L	1.93	< 0.3	<20	<10	<100	300	3.0
W6	0925	H	1.81	< 0.3	<20	<10	<100	360	<3
	1340	L	1.72	< 0.3	<20	<10	<100	20	13
W7	0950	H	2.24	< 0.3	<20	<10	<100	40	<3
	1406	L	2.24	< 0.3	<20	<10	<100	130	<3
W8	0955	H	1.25	< 0.3	<20	<10	<100	50	8.0
	1414	L	1.06	< 0.3	<20	<10	<100	40	9.0
WE	0935	H	1.64	8.8	<20	<10	<100	90	<3
	1348	L	1.49	4.3	<20	<10	<100	100	5.6
WS	0945	H	1.68	0.9	<20	<10	<100	4,700	8.0
	1336	L	1.52	0.8	<20	<10	<100	2,800	9.0

* Feet above sea level

H = High water

L = Low water

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Table 10. Concentrations of mercury, arsenic, lead, nickel, zinc, and cadmium in sediments collected at Stations 3 through 9 on 27 June 1977 (units are mg/kg, or ppm, dry weight basis).

Station No.	Depth (in.)	Hg	As	Pb	Ni	Zn	Cd
3	0-3	882	5	21	5.7	73	0.6
	3-6	695	6	4.8	6.1	63	1.3
	6-9	81	7	0.6	3.3	7.9	0.6
	9-11	13.7	6	1.0	5.9	35	0.5
4	0-3	679	6	155	30	2,116	4.6
	3-6	625	7	65	23	869	3.4
	6-9	179	6	37	23	189	40
5	0-3	11.7	8	31	17	267	2.5
	3-6	23	14	139	141	5,187	45
	6-9	5.7	7	36	15	227	2.9
	9-12	1.2	6	8.3	19	40	1.5
6	0-3	361	7	162	21	428	1.6
	3-6	420	4	149	15	171	0.9
	6-9	624	7	234	16	193	1.0
	9-12	528	4	165	28	302	1.0
7	0-3	2,825	23	480	81	2,723	19
	3-6	39,940	56	554	146	8,615	17
	6-9	89,162	25	439	67	4,032	12
	9-12	66,533	41	450	91	6,153	18
8	0-3	993	38	252	63	802	58
	3-6	307	21	26	36	518	2.1
	6-9	23	10	2.3	21	167	21
	9-12	14.7	6	3.2	29	240	12
9	0-3	57	35	75	47	774	24
	3-6	24	21	45	44	406	6.6
	6-9	5.6	7	18	17	683	2.4
	9-12	23	11	3.9	18	129	6.9

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Table 11. Concentrations of mercury, arsenic, lead, nickel, zinc, and cadmium in samples of water collected at Station 1 on 12 May 1977 (units are ug/l, or ppb).

Collection Time (EST)	Direction of Flow of Water	Hg	As	Pb	Ni	Zn	Cd
0304	Eastward	9.3	11	82	13	230	1.1
0400	Eastward	8.9	13	71	11	200	1.0
0503	Eastward	6.0	35	57	20	200	0.6
0600	Eastward	5.5	38	61	9	190	0.7
0700	Eastward	5.5	17	48	<0.1	170	0.6
0800	Westward	3.2	<10	38	10	200	2.4
0905	Westward	0.9	<10	20	11	190	1.9
1003	Westward	1.3	<10	12	14	170	1.7
1100	Westward =	1.0	<10	10	20	160	1.4
1200	Eastward	1.4	<10	12	16	170	1.9
1300	Eastward	2.8	<10	25	<0.1	170	1.1
1400	Eastward	5.4	<10	17	7	140	1.0
1500	Eastward	10.5	<10	12	<0.1	170	0.9

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At Station 6 on 19 May 1977, the concentrations of mercury were 9.3 ppb and 10.5 ppb at times of low water. During an intervening period of high water, the concentrations were 0.9 ppb and 3.2 ppb (Table 11, Figure 3).

On 8 June 1977 at Station 7, the concentrations of mercury at times of low water were 15.0 ppb and 22.4 ppb. Two concentrations of 1.3 ppb were observed during an intervening period of high water (Table 12, Figure 4). In Berrys Creek, the concentrations of mercury at Station 8 and Station 9 ranged from 0.7 ppb to 2.6 ppb and from 0.7 ppb to 3.5 ppb, respectively, throughout the period from one low water to the next (Table 12). These descriptions omit the results of analyses of samples collected at 1850 and 1955 hours at Station 7, 1845 hours at Station 8, and 1850 hours at Station 9. Procedural errors related to the theft of equipment resulted in the contamination of the samples by entrained sediments.

Samples of water also were collected from Stations 1, 2, 3, 4, and 5 on 8 June 1977 (Table 12). No influence of the tides was detected at Stations 1 and 5 during the period of observations. No samples were collected at Station 2 at 1930 or 2030 because water was no longer flowing. A final sample was collected at 2130, however. Water flowed continuously at Stations 3 and 4, but the depths in the channel were very shallow during the low water stages of the tidal cycle. Owing to the shallowness of the water at most of the stations at the time of sample collection, it also is considered certain that sediments were entrained in the samples of water. Except that they demonstrate the presence of sediments laden with mercury and illustrate the facility with which those sediments can enter the water column, these data are not considered to be valid for use in an appraisal of the condition of surface water at the scene.

On 13 July 1977, concurrent with the withdrawal of samples from the wells, four series of samples were collected from the culvert at Station 7 and from Berrys Creek at Stations 8 and 9 (Table 13, Figure 5). The concentrations of mercury at a period of high water (0800 hours) ranged from 0.7 ppb at Station 8 to 1.4 ppb at Station 9. The concentration at Station 7, at the discharge point, was intermediate (1.0 ppb). During the succeeding three observations, the concentrations at Station 7 ranged from 4.2 ppb to 4.9 ppb. The concentrations at Stations 8 and 9 ranged from 0.5 ppb to 1.6 ppb during the three observations.

4.2. Results of Analyses for Arsenic (As)

4.2.1. Arsenic in the Soil

Concentrations of arsenic that were detected in samples of soil excavated during the installation of eight wells are displayed in Table 5. The results of analyses of samples from 23 stations at which soils were collected by manual techniques are presented in Table 6.

In the well excavations on the Subject Site (Stations W1 through W7), arsenic was present in concentrations that range from 0.6 ppm to 25 ppm (Table 5). Within 2 feet from the surface, at depths equivalent to those represented by the other samples of soil, the concentrations range from 3 ppm (Station W2) to 20 ppm (Station W7).

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Table 12. Concentrations of mercury, arsenic, lead, nickel, zinc, and cadmium in samples of water collected at Stations 1 through 9 on 1 June 1977 (units are ug/l, or ppb).

Station No.	Collection Time (EST)	Hg	As	Pb	Ni	Zn	Cd
1	0940	6.7	<10	<500	<200	130	<50
	1530	27.2	<10	<500	<200	200	<50
	2130	34.0	<10	<500	<200	150	<50
2	0940	72.0	<20	<500	<200	210	<50
	1025	30.0	<30	<500	<200	80	<50
	1120	8.7	<20	<500	<200	30	<50
	1225	47.0	<20	<500	<200	170	<50
	1330	88.0	<20	<500	<200	250	<50
	1425	7.6	<10	<500	<200	40	<50
	1525	1.6	<10	<500	<200	20	<50
	1620	10.7	<10	<500	<200	40	<50
	1725	25.6	<40	<500	<200	90	<50
	1825	19.0	<60	<500	<200	80	<50
	2130	82.0	<40	800	<200	1,500	<50
3	0940	<0.3	<10	<500	<200	20	<50
	1020	0.4	<10	<500	<200	20	<50
	1120	0.7	<10	<500	<200	20	<50
	1220	<0.3	<10	<500	<200	20	<50
	1325	<0.3	<10	<500	<200	20	<50
	1425	<0.3	<10	<500	<200	20	<50
	1525	<0.3	<10	<500	<200	20	<50
	1620	<0.3	<10	<500	<200	20	<50
	1725	<0.3	<10	<500	<200	20	<50
	1825	0.5	<10	<500	<200	30	<50
	1930	<0.3	<10	<500	<200	100	<50
	2030	0.6	<10	<500	<200	40	<50
	2130	<0.3	<10	<500	<200	30	<50
4	0940	0.8	<10	<500	<200	30	<50
	1020	1.0	<10	<500	<200	30	<50
	1120	0.7	<30	<500	<200	20	<50
	1220	0.7	<10	<500	<200	20	<50
	1325	1.9	<10	<500	<200	40	<50
	1425	3.1	<10	<500	<200	60	<50
	1520	3.5	10	<500	<200	80	<50
	1620	2.9	<10	<500	<200	30	<50
	1720	18	<10	<500	<200	150	<50
	1820	1.5	<10	<500	<200	30	<50
	1930	1.4	<10	<500	<200	30	<50
	2030	0.8	<10	<500	<200	20	<50
	2135	1.4	<10	<500	<200	20	<50

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Table 12. Concentrations of mercury, arsenic, lead, nickel, zinc, and cadmium in soil collected on 1 June 1977 (continued).

Station No.	Collection Time (EST)	Hg	As	Pb	Ni	Zn	Cd
5	0940	5.7	<10	<500	<200	150	<50
	1520	11.4	<10	<500	<200	80	<50
	2135	52.0	<10	<500	<200	160	<50
6	0940	3.8	<10	<500	<200	60	<50
	1025	3.4	<10	<500	<200	60	<50
	1125	2.8	<10	<500	<200	40	<50
	1230	4.0	<10	<500	<200	50	<50
	1330	1.0	<10	<500	<200	130	<50
	1430	2.1	<10	<500	<200	130	<50
	1530	2.1	<10	<500	<200	120	<50
	1625	3.1	<10	<500	<200	60	<50
	1735	1.7	<10	<500	<200	40	<50
	1830	5.4	<10	<500	<200	130	<50
	1940	3.0	<10	<500	<200	90	<50
	2035	3.7	<10	<500	<200	70	<50
	2140	3.7	<10	<500	<200	60	<50
7	0950	22.4	<10	<500	<200	220	<50
	1040	11.6	<10	<500	<200	180	<50
	1130	3.1	<10	<500	<200	120	<50
	1240	1.4	<10	<500	<200	130	<50
	1340	1.3	<10	<500	<200	130	<50
	1445	1.3	<10	<500	<200	140	<50
	1545	1.3	<10	<500	<200	110	<50
	1640	6.6	<10	<500	<200	150	<50
	1750	6.5	<10	<500	<200	160	<50
	1850	33.7	<10	<500	<200	220	<50
	1955	49.7	<10	<500	<200	270	<50
	2050	13.2	<10	<500	<200	230	<50
	2150	15.0	<10	<500	<200	230	<50
8	0955	2.6	<10	<500	<200	90	<50
	1030	2.3	<10	<500	<200	90	<50
	1130	1.7	<10	<500	<200	140	<50
	1235	0.9	<10	<500	<200	40	<50
	1335	1.1	<10	<500	<200	130	<50
	1440	1.0	<10	<500	<200	140	<50
	1540	0.7	<10	<500	<200	110	<50
	1630	0.8	<10	<500	<200	130	<50
	1745	0.9	<10	<500	<200	130	<50
	1845	12.8	<30	<500	<200	160	<50
	1945	0.9	<10	<500	<200	80	<50
	2040	1.4	<10	<500	<200	80	<50
	2200	1.6	<10	<500	<200	80	<50

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Table 12. Concentrations of mercury, arsenic, lead, nickel, zinc, and cadmium in samples of water collected on 3 June 1977 (continued).

Station No.	Collection Time (EST)	Hg	As	Pb	Ni	Zn	Cd
9	1005	1.0	<10	<500	<200	70	<50
	1045	1.4	<10	<500	<200	150	<50
	1135	1.0	<10	<500	<200	140	<50
	1245	1.0	<10	<500	<200	150	<50
	1345	1.4	<10	<500	<200	130	<50
	1445	1.0	<10	<500	<200	140	<50
	1550	0.7	<10	<500	<200	120	<50
	1645	0.9	<10	<500	<200	130	<50
	1750	1.0	<10	<500	<200	150	<50
	1850	8.3	<20	<500	<200	180	<50
	1950	2.5	<15	<500	<200	100	<50
	2100	3.5	<10	<500	<200	110	<50
	2200	1.8	<10	<500	<200	110	<50

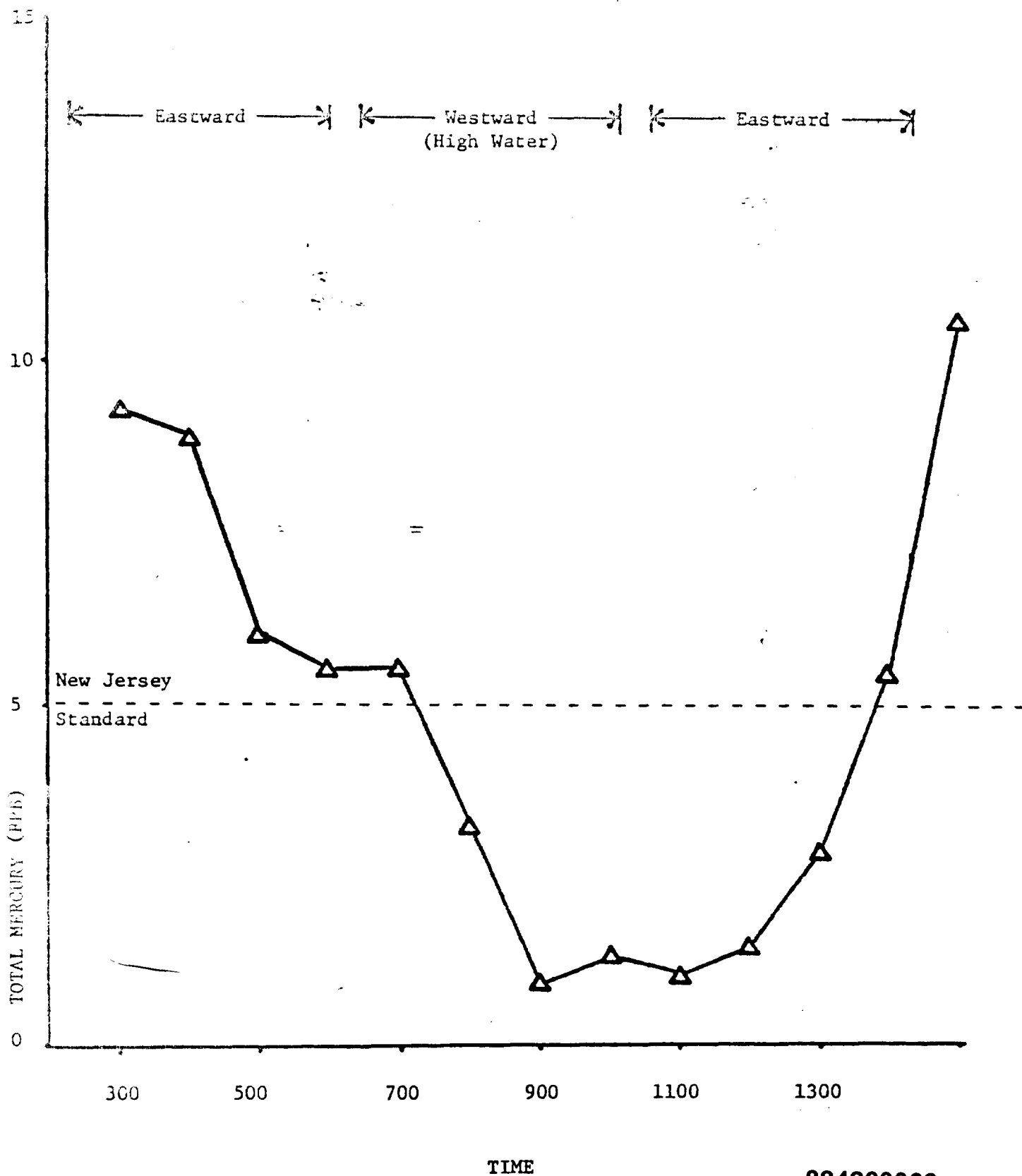
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Table 13. Concentrations of mercury, arsenic, lead, nickel, zinc, and cadmium in samples of water collected from Stations 7 through 9 on 13 July 1973 (units are $\mu\text{g/l}$, or ppb).

Station No.	Collection Time (EST)	Hg	As	Pb	Ni	Zn	Cd
7	0805	1.0	<20	<10	<100	80	18
	0905	4.9	<20	<10	<100	230	19
	1240	4.4	<20	<10	<100	140	11
	1355	4.2	<20	<10	<100	100	5.9
8	0810	0.7	<20	<10	<100	80	20
	0910	0.5	<20	<10	<100	80	16
	1250	1.6	<20	14	<100	160	8.4
	1400	0.7	<20	<10	<100	80	3.9
9	0805	1.4	<20	<10	<100	80	12
	0905	1.3	<20	<10	<100	90	7.7
	1240	0.7	<20	<10	<100	80	<3
	1355	1.5	<20	<10	<100	100	<3

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Figure 3. Variations in the concentration of mercury in samples of water and stream sediment during a period of 12 hours on 19 May 1977. The data are presented in Table 11. The direction of flow of the river is indicated above the graph. Eastward is toward Berry's Creek.



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Figure 4. Concentrations of mercury in samples of water collected at Stations 7(Δ), 8(\circ), and 9(\diamond) in Berrys Creek during a period of 12 hours on 3 June 1977. Source data are presented in Table 12. Readings from a staff gage during this period are plotted on the upper graph (\bullet). The readings are listed in Table 4. The letters H and L indicate the approximate times of high and low water slacks, respectively.

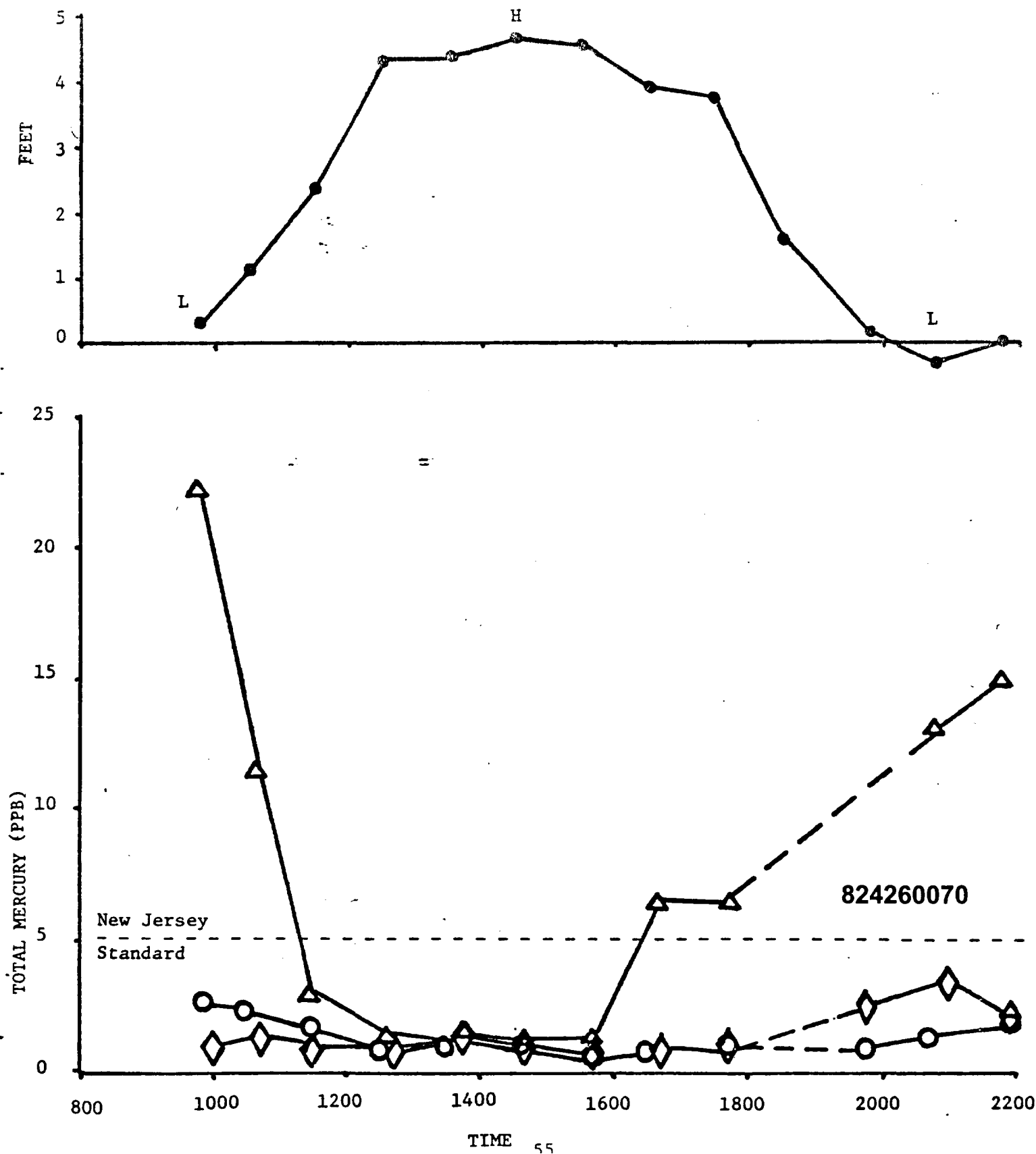
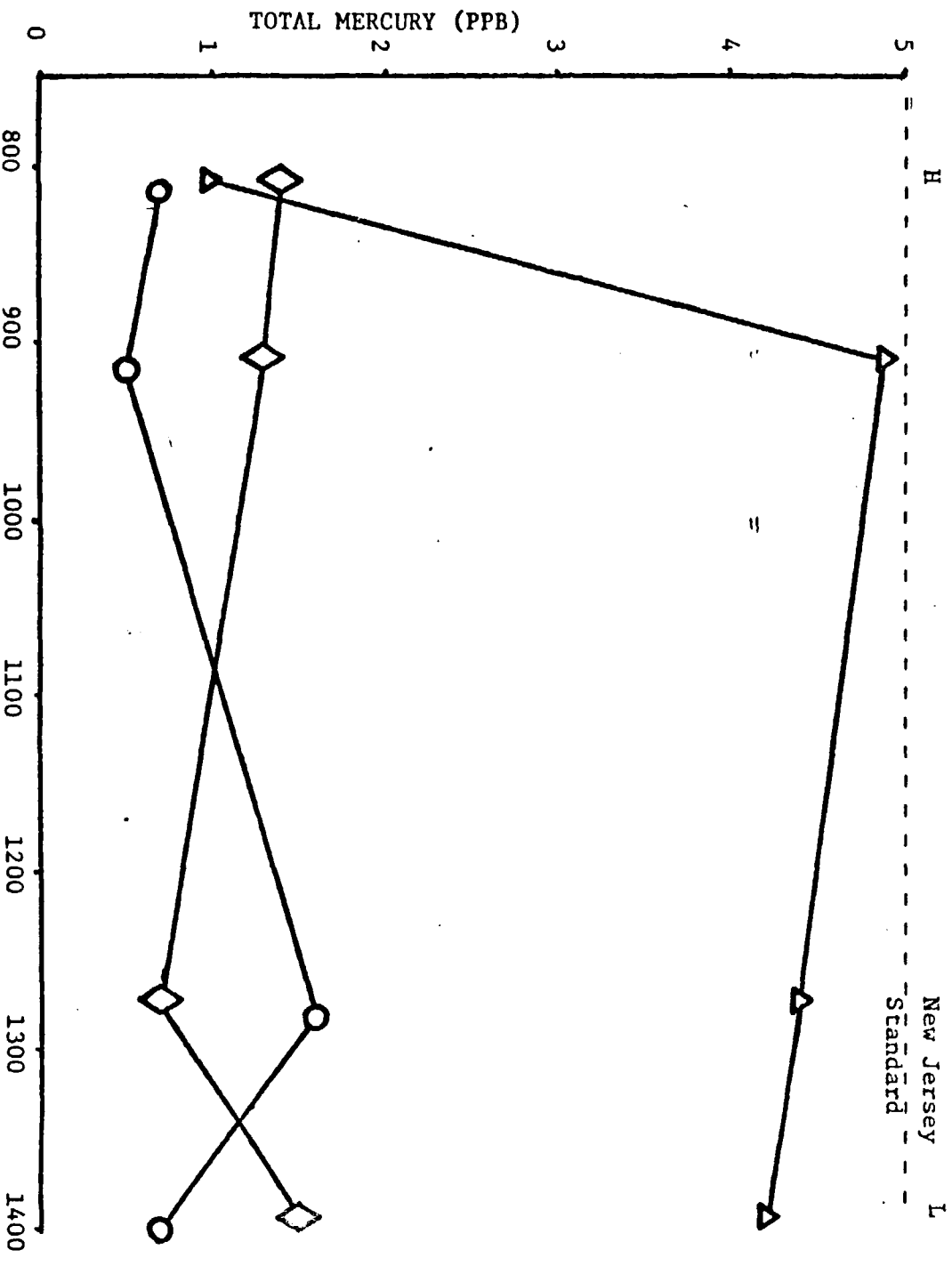


Figure 5. Variations in the concentration of mercury in water collected at Stations 7 (Δ), 8 (O), and 9 (\diamond) in Jersey City during a period of 6 hours on 13 July 1977. Source: data from Table 13. The approximate stage of tide is indicated by H (High) and L (Low) for low water.



Most of the other samples of soil from the Subject Site (Stations 7S through 19S, 23S) contained arsenic in concentrations that range from 5 ppm to 30 ppm (Table 6). The concentrations were notably higher at Station 4S (58 ppm, 64 ppm) and at Station 21S (49 ppm, 82 ppm).

Levels of arsenic in the samples of soil from Station W8, which is near Park Place East, ranged from less than detectable to 5 ppm (Table 5). In the samples of soil from most of the other localities surrounding the Subject Site (Stations 1S, 2S, 3S, 5S, 6S, 20S), the concentrations of arsenic range from 4 ppm to 20 ppm (Table 6). At Station 22, on a marsh peninsula opposite a ditch that extends toward Stations 4S and 21S, the concentrations of arsenic were 45 ppm from 0 to 6 inches and 148 ppm from 6 to 12 inches in depth.

4.2.2. Arsenic in Groundwater

In unfiltered samples of water collected from the wells at Stations W1 through W8 on 2 June and 8 June 1977, the concentrations of arsenic ranged from less than detectable to 31 ppb (Tables 7, 8). In samples drawn on 8 June from the South Well (Station WS) and the East Well (Station WE), the highest concentrations observed were 18 ppb and 78 ppb, respectively.

Samples drawn from the ten wells on 13 July 1977 were filtered before analysis. The concentrations of arsenic in these samples were less than the threshold level of sensitivity of the technique utilized for the analyses (20 ppb; Table 9).

4.2.3. Arsenic in Channel Sediments

The concentrations of arsenic in sediments from the ditches on the Subject Site (Stations 3 through 6) generally ranged from 4 ppm to 8 ppm, with one value of 14 ppm at Station 5 (Table 10). The sediments at the outfall point (Station 7) contained arsenic in concentrations from 23 ppm to 56 ppm. The levels of arsenic in the sediments ranged from 6 ppm to 38 ppm at Station 8, and from 7 ppm to 35 ppm at Station 9.

4.2.4. Arsenic in Surface Water

In thirteen samples of water collected at Station 6 on 19 May 1977, the concentrations of arsenic ranged from less than detectable (eight samples) to 35 ppb and 38 ppb (Table 11). Arsenic was detectable in none of thirteen samples collected at the same station on 8 June 1977 (Table 12).

On 8 June 1977, samples of water also were collected from other stations in drainage ditches on the Subject Site (Stations 1 through 5). Arsenic was not detected in any sample from Station 1, 3, and 5. At Station 2, the concentrations of arsenic in three samples were below the threshold of detection, in four samples they were greater than 10 ppm, but less than 20 ppm, and in four other samples they were in the range from 20 ppb to 60 ppb (Table 12). One sample, of thirteen samples collected from Station 4, contained detectable arsenic (<30 ppb).

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Arsenic was not present in detectable concentrations on 8 June 1977 at the outfall point (Station 7). The concentrations of arsenic in Berrys Creek exceeded detectable limits at Station 9 at 1930 hours on 8 June 1977 (15 ppm). Samples collected from Station 8 at 1845 and from Station 9 at 1850 are considered to be invalid owing to contamination with entrained sediments.

Arsenic was below the level of detectability in samples from the outfall point (Station 7) and from Berrys Creek (Station 8 and 9) on 13 July 1977 (Table 13).

4.3. Results of Analyses for Cadmium (Cd)

4.3.1. Cadmium in the Soil

In samples of soil from Stations W1 through W7, the levels of cadmium range from less than 0.3 ppm to 120 ppm (Table 5). At depths equivalent to those represented in other samples of soil (0 to 2 feet), the concentrations of cadmium range from 1 ppm to 4 ppm.

In other samples of soil from the Subject Site (Stations 4S, 7S through 19S, 21S, and 23S), the concentrations of cadmium range from 1.7 ppm to 86 ppm. At seven of the sixteen stations, the concentration of cadmium did not exceed 10 ppm (9.2 ppm) in any sample.

At Station W8, the range of the observed concentrations of cadmium from the surface to a depth of 14 feet was from less than 0.3 ppm to 0.9 ppm (Table 5). Within 2 feet from the surface, the concentration was 0.9 ppm. At most other localities surrounding the site (Stations 1S, 2S, 3S, 5S, 6S, 20S), the concentrations of cadmium in the upper 12 inches of soil ranged from 1.3 ppm to 4.2 ppm (Table 6). At Station 22S, the concentrations were 31 ppm (0 to 6 inches) and 71 ppm (6 to 12 inches).

4.3.2. Cadmium in Groundwater

The concentrations of cadmium in unfiltered well water drawn on 2 June and 8 June 1977 were below the level of detection (50 ppb) of the technique utilized for analysis (Tables 7 and 8). Samples drawn on 13 July 1977 were filtered before analysis, and the sensitivity of analysis was increased to 3 ppb (Table 9). No cadmium was detected in water from the wells at Stations W1, W2, W3, W4, and W7. The highest concentrations detected at other stations were 5.6 ppb (Station WE), 6.8 ppb (Station W5), 9.0 ppb (Stations W8 and WS), and 13 ppb (Station W6).

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4.3.3. Cadmium in Channel Sediments

In ditches on the subject site, the concentrations of cadmium in the sediments range from 0.5 ppm to 1.3 ppm and 0.9 ppm to 1.6 ppm at Stations 3 and 6 respectively (Table 10). At Stations 4 and 5, the concentrations range from 3.4 ppm to 40 ppm and from 1.5 to 45 ppm, respectively.

The maximum levels of cadmium in sediments in the channel of Berrys Creek were 19 ppm at the outfall point (Station 7), 24 ppm at the downstream station (Station 9), and 58 ppm at the upstream station (Station 8).

4.3.4. Cadmium in Surface Water

In thirteen samples of water collected at Station 6 on 19 May 1977, the concentrations of cadmium ranged from 0.6 ppm to 2.4 ppb (Table 11). The levels of cadmium in all of the samples collected from Stations 1 through 9 on 8 June 1977 were less than the level of sensitivity of the analytical method utilized (Table 12).

On 13 July 1977, the concentrations of cadmium in four samples collected at the outfall point (Station 7) ranged from 5.9 ppb to 19 ppb (Table 13). Concentrations in Berrys Creek during the same period ranged from 3.9 ppb to 20 ppb at Station 8, and from less than 3 ppb to 12 ppb at Station 9.

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4.4. Results of Analyses for Lead (Pb)

4.4.1. Lead in the Soil

In samples of soil collected during the installation of wells on the Subject Site (Stations W1 through W7), the concentrations of lead range from 6 ppm to 14,300 ppm (Table 5). Within 2 feet from the surface, at depths equivalent to those represented by the other samples of soil, the concentrations of lead range from 32 ppm (Station W4) to 280 ppm (Station W6).

The levels of lead in the other samples of soil from the Subject Site (Stations 4S, 7S through 19S, 21S, 23S) range from 11, 44, and 88 ppm to 3,926 ppm (Table 6). Samples from Station 13S contained lead in concentrations between 2,166 ppm and 3,926 ppm from the surface to a depth of 24 inches. Except for Station 10 (1,225 ppm from 0 to 6 inches), the concentrations of lead in the upper 12 inches of soil range from 11 ppm to 913 ppm.

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The concentrations of lead in samples from Station 1S, near Berrys Creek East, range from 5 ppm to 110 ppm (Table 5). Within 2 feet of the surface, the level of lead is 31 ppm. In the samples of soil from other localities around the Subject Site (Stations 1S, 2S, 3S, 5S, 6S, 20S), the levels of lead in the upper 12 inches generally range from 40 ppm to 594 ppm (Table 6). Near Teterboro Airport, at Station 1S, the concentration of lead in the sample from 6 to 12 inches in depth was 5,710 ppm.

4.4.2. Lead in Groundwater

The concentrations of lead in unfiltered water drawn from the wells at Stations W1 through W4, W6 through W7, WE, and WS on 2 June and/or 8 June 1977 were less than the threshold level of detectability of the analytical technique utilized (500 ppb; Tables 7 and 8). The concentrations observed in the well at Station W5 were 1,000 ppb and 3,000 ppb on 2 June, and 1,400 ppb on 8 June 1977.

In filtered samples of water that were drawn from the ten wells on 13 July 1977, the concentrations of lead were less than the threshold level of detectability of the analytical technique utilized (10 ppb; Table 9).

4.4.3. Lead in Channel Sediments

The concentrations of lead in the sediments in the system of open ditches on the Subject Site (Stations 3, 4, and 5) range from 0.6 ppm to 155 ppm (Table 10). At Station 6, the concentrations range from 149 ppm to 234 ppm. In Berrys Creek at the outfall point (Station 7), the sediments contain lead in concentrations that range from 439 ppm to 554 ppm. Upstream and downstream from the discharge point, the concentrations of lead in the sediments range from 2.3 ppm to 252 ppm and from 3.9 to 75 ppm, respectively.

4.4.4. Lead in Surface Water

The levels of lead in thirteen samples collected on 19 May 1977 at Station 6 ranged from 10 ppb to 82 ppb (Table 11). Except for one determination at Station 2 (800 ppb), the concentrations of lead in all of the samples collected from Stations 1 through 9 on 8 June 1977 were less than the threshold level of detectability of the analytical technique utilized (500 ppb; Table 12).

Samples of water were collected from the outfall point (Station 7) and from the stations on Berrys Creek (Stations 8 and 9) at four times on 13 July 1977. The concentrations of lead in eleven of the samples were less than the threshold level of detectability for the analytical technique utilized (10 ppb; Table 13). In a sample collected from Station 8 at 1250 hours, the concentration of lead was 14 ppb.

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4.3. Results of Analyses for Nickel (Ni)

4.3.1. Nickel in the Soil

The concentrations of nickel in samples of soil from Stations W1 through W7, which include materials from as deep as 18 feet beneath the surface, generally are from 6 ppm to 94 ppm (Table 5). The surface 2-foot sample from Station W1 contains nickel at a concentration of 110 ppm. The range of concentrations in the upper 2 feet at the other stations is from 11 ppm to 90 ppm.

In samples of soil from other stations on the Subject Site, nickel is present at concentrations that range from 19 ppm to 240 ppm (Table 6). Within 12 inches from the surface, the range of concentrations in the samples is from 19 ppm to 213 ppm.

At stations in the surrounding area, the concentrations in nickel in samples from as deep as 14 feet beneath the surface at Station W8 range from 7 ppm to 14 ppm (Table 5). In the sample of the surficial 2 feet, the concentration is 14 ppm. At six of the other seven stations (1S, 2S, 3S, 5S, 6S, 20S), the levels of nickel in the soil within 12 inches of the surface ranged from 7.8 ppm to 41 ppm (Table 6). Samples of marsh soil from Station 22 contain nickel at concentrations of 211 ppm in the layer from 0 to 6 inches in depth, and of 289 ppm in the layer from 6 to 12 inches in depth.

4.3.2. Nickel in Groundwater

Concentrations of nickel in samples of water drawn from the various wells during June and July 1977 were less than the threshold levels of detection associated with the analytical techniques utilized (200 ppb and 100 ppb; Tables 7, 8, and 9).

4.3.3. Nickel in Channel Sediments

The concentrations of nickel in samples of sediment collected from the drainage ditch at Station 3 range from 3.3 ppm to 6.1 ppm (Table 10). At other stations in the drainage system on the Subject Site (Stations 4, 5, and 6), nickel is present in the sediments at concentrations that generally range from 15 ppm to 30 ppm. The concentration in a sample of materials from a depth of 3 to 6 inches at Station 5 is 141 ppm.

The sediments in the channel of Berrys Creek at the outfall point (Station 7) contain nickel in concentrations from 67 ppm to 146 ppm (Table 10). The concentrations at the upstream station (Station 8) and at the downstream station (Station 9) range from 21 ppm to 63 ppm, and from 17 to 47 ppm, respectively.

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4.5.4. Nickel in Surface Water

In a series of thirteen samples of water collected on 19 May 1977 at Station 6, the levels of nickel varied from less than 0.1 ppb (three samples) to 20 ppb (two samples). The concentration of nickel in all samples of water collected from stations on and near the site on 8 June and 13 July 1977 were less than the threshold of sensitivity of the analytical techniques utilized (200 ppb and 100 ppb; Tables 12 and 13).

4.6. Results of Analyses for Zinc (Zn)

4.6.1. Zinc in the Soil

The concentrations of zinc in samples of soil from depths as great as 14 feet at Station W8 range from 19 ppm to 280 ppm (Table 5). The surficial materials, from a depth of 0 to 2 feet, contain zinc in a concentration of 280 ppm. In soils from upland sites in other localities surrounding the subject site (Stations 1S, 2S, 3S, 5S, 6S, 20S) the concentrations of zinc in the topmost foot range from 42 ppm to 426 ppm (Table 6). Samples of marsh soil from Station 22 contain zinc at concentrations of 4,286 ppm (0 to 6 inches) and 10,670 ppm (6 to 12 inches).

In samples of soils from the excavations for wells at Stations W1 through W7 on the Subject Site, the concentrations of zinc range from 23 ppm to 11,500 ppm (Table 5). The concentrations in the upper 24 inches of soil range from 170 ppm (Station W7) to 6,000 ppm (Station W1).

The levels of zinc in samples of soil to a depth of 12 inches of soil at other locations on the Subject Site (Stations 4S, 7S through 19S, 21S, 23S) range from 315 ppm to 28,832 ppm (Table 6). The concentrations in the underlying soil, from 12 to 24 inches in depth, range from 294 ppm to 13,634 ppm.

4.6.2. Zinc in Groundwater

In unfiltered samples of water drawn from wells at Stations W1 through W8 on 2 June 1977, the concentrations of zinc ranged from 30 ppb to 380 ppb at six stations (Table 7). The concentrations in samples from the top of the screened section of the casing and from the bottom, respectively, were 110 ppb and 22,400 ppb in the well at Station W2, and 21,300 ppb and 25,200 ppb in the well at Station W5.

Samples of water were drawn from the wells at Stations W1 through W8 again, and from the wells at Stations WE and WS, on 8 June 1977 (Table 8). The concentrations of zinc in these unfiltered samples ran from 20 ppb to 190 ppb at Stations W1 through W4, W6 through W8, and WE. The values obtained from samples collected at times of low water and times of high water in Berrys Creek, respectively, were 11,200 ppb and 4,500 ppb at Station 5 and 4,500 ppb and 3,400 ppb at Station WS.

5. SUMMARY OF THE RESULTS

This section is a vehicle for interpretations of the basic data contained in Section 4, and for the expression of opinions in regard to the distribution, origins, and importance of the various metals detected on the Subject Site and in its vicinity.

5.1. Mercury

5.1.1. Mercury in the Soil

The concentrations of mercury in natural soils generally do not exceed levels of about 1 ppm except for those in the vicinity of bodies of ore (Table 14). The results of the analyses of composited samples of soil collected during this investigation from the Subject Site indicate that the concentrations of mercury in the soil on the property of the Velsicol Chemical Corporation, to a depth of 18 feet, ranged from 0.7 ppm to 123,000 ppm (Tables 5 and 6). Within 24 inches from the surface, the mean concentrations of mercury in the soil at Stations on the Velsicol property ranged from 2 ppm to 30,890 ppm (Figure 6).

The stations at which mean concentrations of mercury in the soil within 24 inches from the surface exceed 1,000 ppm are in the area from the southeast wall of the building on the property of Wolf Realty southeastward to Station 14S (Stations 23S, W6, 13S, and 14S; Figure 6). The mean concentrations of mercury in the surficial soils at seven stations on the Velsicol property range from 100 to 1,000 ppm: W7 (193 ppm), 8S (272 ppm), W5 (419 ppm), W1 (273 ppm), 4S (682 ppm), 21S (995 ppm), and 19S (142 ppm). Mean concentrations of mercury less than 100 ppm were observed at twelve stations on the property: 10S (20 ppm), W4 (2 ppm), 11S (23 ppm), 12S (52 ppm), 16S (27 ppm), 9S (19 ppm), 7S (8 ppm), W2 (3 ppm), 15S (7 ppm), 17S (13 ppm), W3 (20 ppm), and 18S (10 ppm).

At two nearby stations, the mean concentration of mercury in the first 24 inches of the soil exceeded 100 ppm: W8 (432 ppm) and 22S (776 ppm). The mean concentration of mercury at Station 20S was 36 ppm, and that at Station 3S was 4 ppm (Figure 6).

The sections of the Subject Site that is formed by the properties owned by the United States Life Insurance Company and by Wolf Realty are covered almost completely by large warehouse buildings and pavement. It was not possible to obtain samples of soil without destructive effects on the artificial surfaces. The presence of mercury and other heavy metals on the Wolf Realty property, however, is well documented by investigations conducted for the Rovic Construction Company, Inc., by the United States Testing Company, Inc., during July 1974 and August 1975,

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Samples taken at the outfall point (Station 7) indicate that the concentrations of zinc in the water ranged from 110 ppb to 230 ppb during the 13-hour period (Table 12). The values for samples taken at 1850 and 1955 hours are discounted owing to the entrainment of sediments.

The levels of zinc in the West Riser Ditch of Berrys Creek at Station 8 ranged from 40 ppb to 140 ppb on 8 June 1977 (Table 12). The reading of 160 ppb is believed to reflect entrainment. At Station 9 on Berrys Creek, the levels of zinc varied from 70 ppb to 150 ppb during the day. The value of 180 ppb is discounted.

In samples of water collected at the outfall (Station 7) on 13 July 1977, the concentration of zinc was 80 ppb at the time of high water, it then increased to 230 ppb as the water level began to fall, and was 140 ppb and 100 ppb at later times during the period of ebb (Table 13). At Stations 8 and 9 on Berrys Creek, the sequences of concentrations of zinc during the same span of time were, respectively: 80/80 ppb, 80/90 ppb, 160/80 ppb, 80/100 ppb.

4.7. Proof of Connection Between Stations 4 and 6

Red food coloring that was added to the water in the ditch at Station 4 1300 EST was observed in the water at Station 6 at 1400 hours. The transit time is not known precisely, but was less than 1 hour.

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Table 1-1. Criteria, guidelines, and regulations for the maximum concentrations of certain metals in various media.

Units:	Soil ^a	Sediments ^b	Groundwater ^c	Surface Water	
	ppm	ppm	ppb	State ^e ppb	Federal ^f ppb
Arsenic	5.0	8.0	50	50	50 ^f
Cadmium	0.5	5.0	10	10	5 ^f
Lead	150.0	50.0	50	50	50 ^g
Mercury	1.0	1.0	2	5	0.1 ^f
Nickel	13.0	60.0	5,000	NA	100 ^f
Zinc	44.0	180.0	5,000	NA	100 ^g

^a These are mean or geometric mean concentrations in soils throughout the conterminous United States, from Curry and Gigliotti (1972) and Shacklette and others (1971).

^b The sources are listed in text.

^c US-EPA. (1975).

^d Zinc level is a recommendation from Committee on Water Quality Criteria 1972, p. 93, and is based on taste and not on health aspects. Nickel level is from the same source, p. 181, but is based wholly on toxicity to fish and not to humans; it is inserted only as a point of reference.

^e New Jersey Department of Environmental Protection (1975).

^f Committee on Water Quality Criteria (1972). Criteria are for the protection of marine aquatic life, and are given on the following pages: Lead, p. 174; Zinc, p. 257.

^g US-EPA (1976): Criteria are for the protection of marine aquatic life, and are given on the following pages: Arsenic, p. 30; cadmium, p. 50; nickel, p. 198.

NA means Not Available as a finite limit.

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Another series of samples was drawn from the ten wells on 13 July 1977. In these samples, which were filtered before analysis, the concentrations of zinc ranged from 10 ppb to 360 ppb at Stations W1 through W8 and WE (Table 9). Samples taken at high and low water, respectively, at Station WS contain zinc in concentrations of 4,700 ppb and 2,800 ppb.

4.6.3. Zinc in Channel Sediments

The levels of zinc in the sediments of the drainage ditch at Station 3 range from 7.9 ppm to 73 ppm (Table 10). At nearby stations, the levels range from 189 ppm to 2,116 ppm (Station 4) and from 40 ppm to 5,187 ppm (Station 5). The concentrations in the sediments at Station 6, which is an intermediate point in the drainage system, range from 171 ppm to 428 ppm. At the discharge point (Station 7), the sediments in the channel of Berrys Creek contain zinc at concentrations from 2,723 ppm to 8,615 ppm. The sediments in Berrys Creek upstream and downstream from the discharge point have levels of zinc that range from 167 ppm to 802 ppm (Station 8) and from 129 ppm to 774 ppm (Station 9).

4.6.4. Zinc in Surface Water

The concentrations of zinc in thirteen samples that were collected at Station 6 on 19 May 1977 range from 140 ppb (one sample) to 200 ppb (three samples) and 230 ppb (one sample; Table 11). In a similar series of samples collected at Station 6 on 8 June 1977, the concentrations of zinc range from 40 ppb (two samples) to 130 ppb (three samples; Table 12).

Samples of water also were collected from Stations 1 through 5 and 7 through 9 on 8 June 1977 (Table 12). At stations 1 and 2, which are in a paved swale, the recorded concentrations of zinc ranged from 20 ppb to 1,500 ppb. These samples, however, also certainly were contaminated by entrained sediments that were stirred during the collecting operation. Except for their indication of the condition and mobility of the sediments, these values should be discounted from analyses of the condition of the surface waters.

The results of the analyses of samples of water from Stations 3 and 4 indicate that concentrations of zinc generally range from 20 ppb to 30 or 40 ppb (Table 12). Higher values for analyses from these stations, especially those in excess of 100 ppb, almost certainly reflect the entrainment of sediments and should be discounted. Similarly, the values from Station 5 are considered to reflect entrainment.

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and by the US Testing Laboratories, Inc., during September 1974. Allegedly, the soils that were most heavily contaminated with mercury (10,000 ppm or more) later were removed from the Insurance Company property and were placed within the containment on the Wolf Realty property. There now should be a greater total amount of mercury on the Wolf Realty property, therefore, than was present before the soil transfer was conducted.

The July 1974 survey was based on 36 samples of soil from the surface to a depth of 3 feet at nine sites (Table 15). Concentrations of mercury as high as 195,000 ppm were observed, and the minimum was 215 ppm. The average concentration of mercury in the 36 samples was 26,900 ppm.

Ninety-three samples of soil were taken from the surface to depths as great as 3 feet at 34 stations on the Wolf Realty property during September 1974. The stations were arranged in a rectangular grid (Figure 7). The concentrations of mercury determined in the samples ranged from 30 ppm to 142,500 ppm. The average concentration of mercury in the samples was 12,800 ppm (Table 16).

These previous surveys document that mercury is present at extraordinarily high concentrations in the soil on the Wolf Realty property. The average concentration of mercury calculated from the results of the surveys by the US Testing Company during July 1974 is more than twice as great as that calculated from the results of the analyses conducted by the New Jersey Testing Lab on soil collected during September 1974. Because the September survey included more than twice as many samples as did the July survey, and because it results in a lower (i.e., more conservative) estimate, that survey is used to estimate the minimum amount of mercury on the 1.89 acres of the Wolf Realty tract that was investigated.

The dry bulk density of an average soil is approximately 1.3 grams per cubic centimeter (Hillel 1971). This is equivalent to about 80 pounds per cubic foot (1 cubic foot = 28,317 cubic centimeters; 1 pound = 453 grams; $28,317 \times 1.3 \div 453 = 81.3$, round to 80 pounds). In an area of 1.89 acres to a depth of 3 feet, there are approximately 247,000 cubic feet of soil ($1.89 \times 43,560$ square feet \times 3 feet). If each cubic foot of soil weighs 80 pounds, the total volume of soil weighs 19.75 million pounds. If the concentration of mercury in the soil is 12,800 ppm (12,800 pounds of mercury per 1 million pounds of soil), there are 252,910 pounds of mercury on the 1.87 acre area. This equals 126 tons of mercury.

The same formula can be used to calculate the approximate amount of mercury present on that part of Velsicol property from which samples of soil were collected (Figure 6). The section of the property that is situated generally to the north of the ditch that is located between Station 4S and Station 7S contains about 19 acres. The mean concentrations of mercury in the soil, based on the determinations on samples within 2 feet of the surface at wells W1 through W7, Stations 7S through 19S, and Station 23, is 1,876 ppm. An unusually high concentration, however, was detected at Station 14S. If this datum is omitted from the calculation, the estimate of the mean concentration of mercury in the soil is 425 ppm.

Table 15. Concentrations of selected metals in samples of soil collected during July 1974 from Lot 10, Block 229 on the Subject Site (W7-22). Descriptions of the specific locations of the test areas are not available. Data are expressed in parts per million (ppm). A zero in the column for depth means surface. Other depths are expressed in feet.

Site	Depth	Arsenic	Cadmium	Lead	Mercury	Nickel	Zinc
1	0	6.8	2.6	24.0	415	26.0	590.0
	1	4.6	< 2.0	1,980.0	215	22.0	235.1
	2	3.0	2.2	16.8	2,175	16.6	147.5
	3	7.8	< 2.0	4.8	185	13.0	88.2
2	0	8.0	3.8	130.0	515	35.4	2,412.0
	1	11.9	< 2.0	46.8	265	26.6	174.6
	2	10.4	< 2.0	40.6	315	31.0	282.2
	3	6.8	< 2.0	45.0	275	27.4	291.9
3	0	10.2	< 2.0	43.0	3,215	21.6	156.2
	1	23.9	< 2.0	2.6	1,825	28.2	229.2
	2	27.2	< 2.0	38.4	1,450	38.2	201.8
	3	3.4	< 2.0	4.6	930	6.8	75.7
4	0	17.1	5.2	620.0	7,625	95.8	1,188.0
	1	9.6	2.2	63.0	18,750	23.0	475.0
	2	9.7	< 2.0	57.0	3,425	20.0	1,030.0
	3	8.0	< 2.0	10.2	6,875	13.4	100.0
5	0	11.1	8.3	380.0	10,750	162.6	8,760.0
	1	19.3	< 2.0	13.6	13,750	51.8	208.8
	2	21.1	< 2.0	103.2	16,750	99.6	2,530.0
	3	25.0	4.0	120.0	47,000	326.0	9,680.0
6	0	24.3	2.4	66.8	1,825	68.0	2,000.0
	1	35.6	< 2.0	17.4	16,250	52.0	5,020.0
	2	35.9	< 2.0	18.0	5,625	52.6	8,220.0
	3	22.0	< 2.0	21.6	39,500	45.4	1,614.0
7	0	21.1	4.5	52.6	9,500	92.8	2,652.0
	1	9.7	2.6	23.2	8,250	55.8	1,670.0
	2	7.7	92.2	408.0	67,500	40.2	76,500.0
	3	8.3	4.9	22.4	1,775	14.2	2,896.0
8	0	6.0	3.5	277.6	182,500	1,076.0	66,740.0
	1	2.8	27.9	216.8	29,500	177.6	56,100.0
	2	3.4	18.3	268.6	195,000	162.4	8,560.0
	3	3.3	2.5	141.4	117,500	150.0	2,360.0
9	0	2.1	< 2.0	73.0	82,500	29.8	600.0
	1	2.7	2.2	116.0	9,500	94.0	4,560.0
	2	2.3	4.8	168.4	23,000	114.0	3,440.0
	3	2.5	< 2.0	68.0	43,000	44.0	785.0
Mean		12.0	5.9	158.0	26,900	92.0	7,570.0
Maximum		35.9	92.2	1,980.0	195,000	1,076.0	76,500.0

Table 16. Concentrations (levels) of mercury in samples of soil collected during September 1974 from the property owned by Wolf Realty (WV-19). The locations of the sites are plotted on Figure 7. Codes for depths are defined in a footnote at the end of the table. Data are expressed as parts per million (ppm).

Site	Depth	Level	Site	Depth	Level	Site	Depth	Level
B-1	A	19,000	D-1	0	3,000	E-4	0	4,750
	B	88,350		1	1,330		1	23,750
	C	19,000		2	1,330		2	6,270
B-2	0	16,530	D-2	0	14,250	E-5	0	54,150
	1	8,930		1	5,700		1	47,500
	2	1,900		2	5,130		2	7,600
B-3	2	6,270	D-3	0	4,750	F-1	0	99,750
				1	4,560		1	2,470
B-4	0	7,600		2	1,330		2	1,900
	1	1,520	D-4	0	1,520	F-2	0	4,750
	2	2,850		1	17,480		1	1,900
C-1	1	5,510		2	2,280		2	1,900
	2	3,040	D-5	0	22,800	F-3	D	3,990
C-2	1	7,880		1	7,220		E	1,610
	2	3,040	E-1	0	2,140		F	6,360
C-3	1	6,080		1	7,980	F-4	0	760
	3	5,890		2	4,750		1	80
C-4	0	19,000	E-2	1	3,420		2	3,230
	1	3,040		2	7,980	F-5	0	1,000
	2	1,900	E-3	0	48,450		1	113,000
C-5	G	2,470		1	10,830			102,000
				2	2,470			

Table 16. Concentrations (levels) of mercury in samples of soil collected during September 1974 from the property owned by Wolf Realty (continued).

Site	Depth	Level	Site	Depth	Level
G-1	0	3,800	H-3	0	90
	1	1,430		1	50
	2	2,850		2	1,520
G-2	0	1,000	H-4	0	70
	1	950		1	70
	2	3,230		2	30
G-3	0	37,260	H-5	0	7,560
	1	19,000		1	9,500
	2	1,630		2	10,830
G-4	0	3,040	MEAN		12,800
	1	11,020			
	2	1,440	MAXIMUM		142,500
G-5	0	1,620			
	1	72,920			
	2	24,130			
H-1	0	1,800			
	1	1,520			
	2	2,850			
H-2	0	2,470			
	1	14,250			
	2	1,520			

^aCodes for depths are; 0, surface or 6 or 8 inches to 12 inches in depth. 2, from 1 to 2 feet in depth; 2, from 2 to 3 feet in depth; A, 0.75 to 1.75 feet; B, 1.75 to 2.75 feet; C, 2.75 to 3.0 feet; D, 0.5 to 1.5 feet; E, 1.5 to 2.5 feet; F, 2.5 to 3.0 feet; G, collected by a backhoe, depth not specified

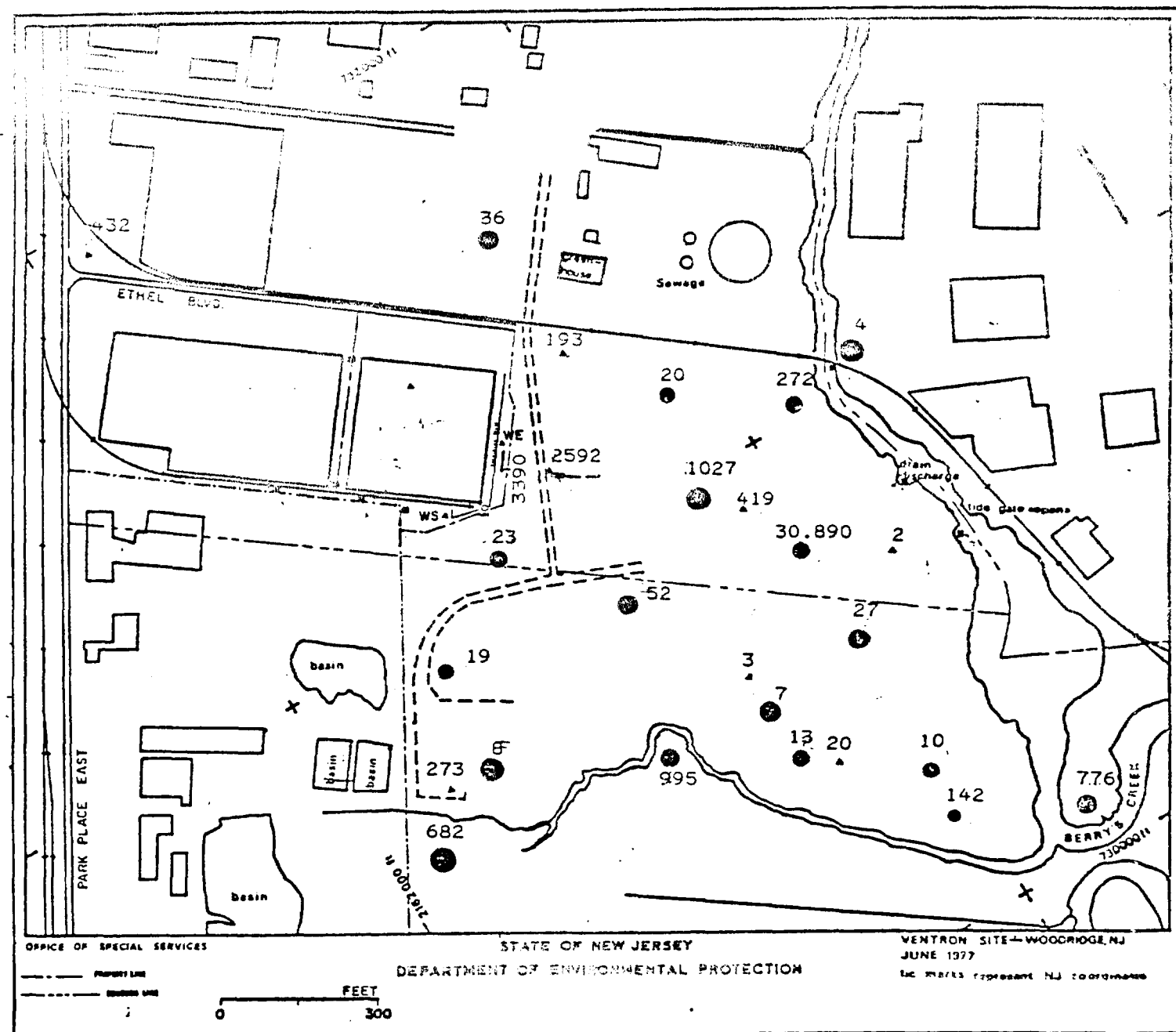


Figure 6. Mean concentrations of mercury in the surficial 24 inches of soil.

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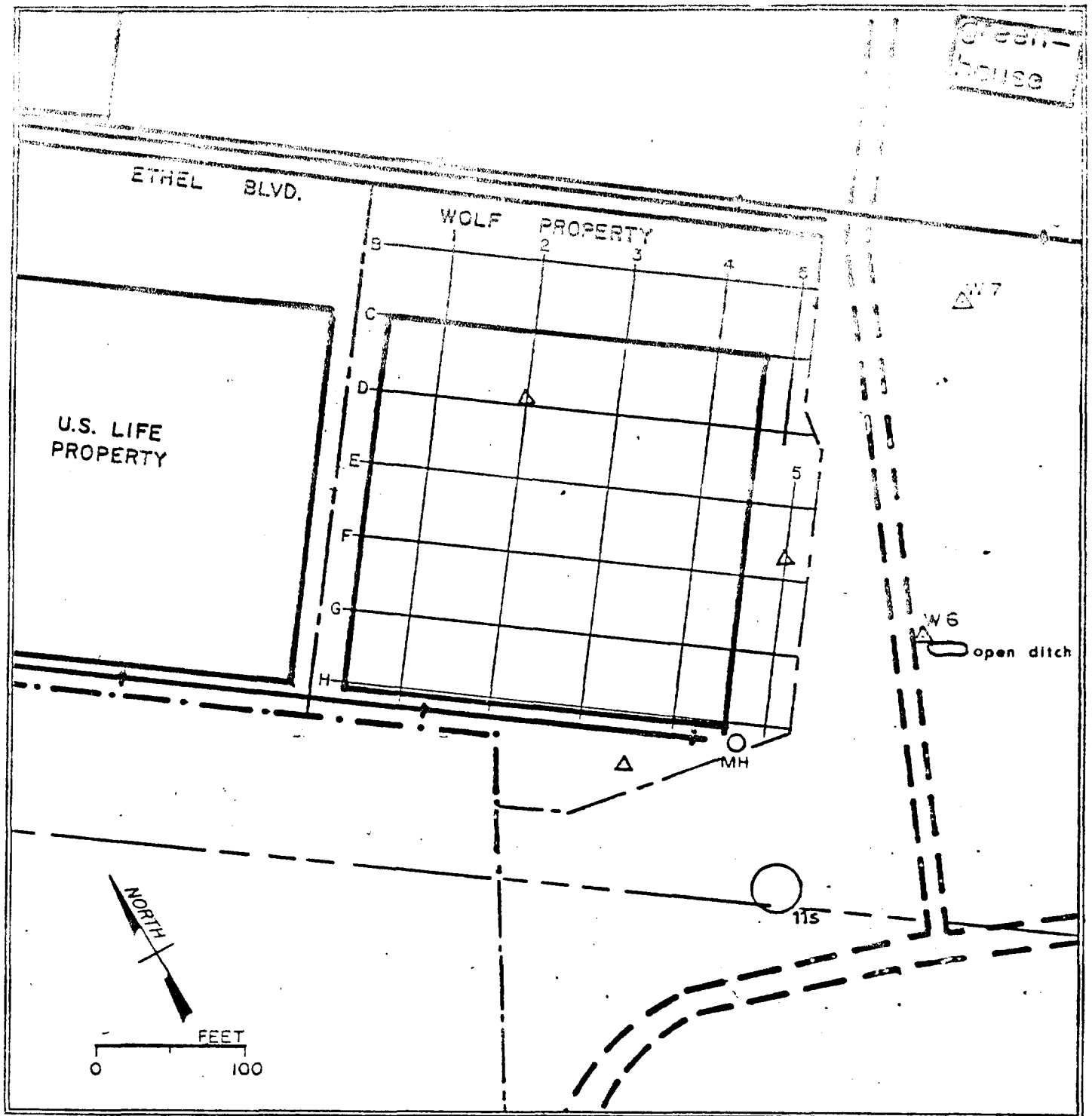


Figure 7. Grid pattern utilized to select sites from which samples of soil were collected by the New Jersey Testing Laboratories, Inc., during September 1974 (WV-18). The results of analyses for mercury are displayed in Table 16.

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Using this more conservative estimate, the total amount of mercury present in the 19 acres, within 2 feet from the surface, is 28 tons (19 acres X 43,560 square feet X 2 feet X 80 pounds = 132 million pounds X 425 pounds of mercury ÷ 2,000 pounds = 28 tons).

The average concentration of mercury in thirteen samples of soil from the northerly part of the Velsicol property at depths from 2 feet to 10 feet in the seven well cores (Table 5) is 567.55 ppm. To be conservative, the value of any sample that exceeded 1,000 ppm can be discounted to 1,000 ppm. The revised average concentration, then is 504 ppm. Using the same formula, this conservative average indicates that there are 133 tons of mercury in this 8-foot thick section of soil on the part of the Velsicol property that was investigated. The total amount of mercury on the Velsicol tract, therefore, must exceed 160 tons.

The presence on the Subject Site of soil that is contaminated with several tons of mercury is a substantial hazard to public health, to terrestrial wildlife, and to the aquatic environment. Except where it has been covered or disturbed recently, the surface of the soil throughout the Subject Site is vegetated. Particularly on the property owned by the Velsicol Chemical Corporation, tall stands of plume grass (Phragmites communis) and other plants provide a dense cover that is utilized by cottontail rabbits, pheasants, and other wildlife. The plants that grow in the contaminated soil certainly contain measurable concentrations of mercury. Rabbits, which eat the foliage, pheasants, which eat the seeds, and other herbivorous wildlife, thus ingest mercury in their foods.

Particles of soil that are blown by the wind, carried by storm runoff, or which adhere to footwear, clothing, or vehicles may be carried off of the site and thereby will contaminate other areas. Particularly, soil materials that are carried into Berrys Creek will contaminate the aquatic environment.

Mercury also may vaporize and be transported to other areas by means of air movements. Insoluble forms of mercury also may be transformed biologically or abiologically to other forms, particularly to organic forms, which are soluble and can be carried by surface water and/or by groundwater.

Persons who visit or work on the Subject Site are exposed directly to the mercury-bearing soils. Mercury that enters wildlife may reach humans who hunt or trap for game. Fishermen and crabbers may be exposed to mercury that enters the aquatic environment. Mercury carried in the air as a vapor or on particulate matter may enter the bodies of human beings through the respiratory system.

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5.1.2. Mercury in Groundwater

The US-EPA maximum contaminant level for mercury in drinking water at the point where such water enters the distribution system is 0.002 mg/l, or 2 ppb (Table 14). The concentrations of mercury in filtered samples of water drawn from wells at Stations W1 through W8 on or near the Subject Site on 13 July 1977 were less than 0.3 ppb (Table 9). Soluble mercury does not appear to be reaching the groundwater at these stations. In samples of water from the South Well (Station WS), the concentrations of mercury were 0.8 ppb and 0.9 ppb (Table 9). Although these levels do not exceed the standard, they demonstrate that a source of dissolved mercury is present at Station WS. The observed levels of mercury in the East Well (Station WE), 4.3 ppb and 8.8 ppb, substantially exceed the standard. The groundwater at Station WE, therefore, can be considered to be polluted by mercury. The water represents a threat to the aquatic environment, and it is a potential hazard to human health.

In summary, measurable concentrations of mercury were found in filtered samples from wells at Stations WE and WS, but not in samples from wells at Stations W1 through W8. The results of an analysis of a sample of water drawn by William Althoff of NJ-DEP from the well inside of the building on the Wolf Realty property on 8 March 1977 show that the total concentration of mercury in an unfiltered sample was 67.0 ppb, and that the concentration of dissolved mercury (filtered sample) was 66 ppb. These facts indicate that groundwater on the property owned by Wolf Realty, both inside and outside of the building, contains dissolved mercury, and that the concentrations of dissolved mercury are high enough to present a hazard to the health of human beings. The facts indicate further that the containment system installed during the construction of the building is not functioning properly. The concentration gradient (66 ppb inside containment system; 4.3 ppb and 8.8 ppb at the East Well, and 0.8 ppb and 0.9 ppb at the South Well, outside of the building) indicates that dissolved mercury is moving from the building (containment system) to the East Well and the South Well.

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5.1.3. Mercury in Channel Sediments

No finite concentration can be said universally to represent the threshold of contamination in sediments from stream channels. Sediments that contain mercury in excess of 0.2 ppm probably are contaminated, and sediments that contain mercury in excess of 1.0 ppm almost certainly are contaminated (McCormick 1976). Based on this criterion, the 15 samples of sediment collected from four stations on the Subject Site (Stations 3, 4, 5, and 6) and the 12 samples of sediment collected from the channel of Berrys Creek (Stations 7, 8, and 9) all are contaminated with mercury (Table 10).

In the perspective of the natural condition of sediments, which is characterized by studies of sediments in other localities, all of the sediments from the Subject Site and from nearby places in Berrys Creek are contaminated grossly. To facilitate this narrative description, however, four arbitrary ranges of concentrations of mercury can be recognized: less than 100 ppm; 100 to 499 ppm; 500 to 899 ppm; and greater than 899 ppm. The results of the analyses (Table 10) are rearranged according to these categories in the following tabulation:

<100 ppm	100-499 ppm	500-899 ppm	>899 ppm
#3 6-11 in.	#4 6-9 in.	#3 0-6 in.	#7 0-12 in.
#5 0-12 in.	#6 0-6 in.	#4 0-6 in.	#8 0-3 in.
#8 6-12 in.	#8 3-6 in.	#6 6-12 in.	
#9 0-12 in.			

Water is known to flow from Station 3 to Station 4, thence through a buried culvert to Station 6, through an open ditch to the invert of another buried culvert, and thence through the culvert to its end at Berrys Creek (Station 7). The surficial sediments (0 to 3 inches) at Stations 3 and 4 contain mercury at concentrations of 882 ppm and 679 ppm; those at Station 6 contain 361 ppm mercury; and those at Station 7 contain 2,825 ppm (Table 10). There is a direct pathway for the movement of mercury from Station 3, on the United States Life Insurance Company property, to Station 4, on the property of Wolf Realty, to Station 6, on the property of the Velsicol Chemical Corporation, and to Station 7 and Berrys Creek.

Several samples of surface water were contaminated by sediments that were entrained during the collecting operations (Section 5.1.4.). These incidents demonstrate (1) that sediments contaminated by mercury also occur in the paved swale at Stations 1 and 2, and (2) that the contaminated sediments in the swales, ditches, and culverts on the Subject Site, as well as those in Berrys Creek, are mobilized easily and remain in suspension in the water column, at least temporarily. The contaminated sediments in the swales, ditches, and culverts on the Subject Site, therefore, can be transported to Berrys Creek by upland runoff and/or by the action of the tides. These sediments are hazards to the aquatic environment of Berrys Creek and the waters to which it is a tributary. Rabbits, pheasants, and other wildlife also may be exposed to the ingestion of mercury on sediments roiled as the animals drink from ditches on the Subject Site.

The observed concentrations of mercury in the sediments at Stations 3, 4, 6, and 7 follow a logical progression. Because the stations are hydraulically connected and are affected by the rise and fall of the tide, one could expect the concentrations of mercury to be approximately equal in the sediments. If mercury-rich materials were discharged or deposited at one of the stations, the concentration of mercury in the sediments at that station would be expected to be higher than the concentrations in the sediments at the other stations. In point of fact, the concentrations of mercury in the sediments at Stations 3, 4, and 6 are relatively similar -- 361 ppm to 882 ppm in the upper 6 inches. The concentrations of mercury in the upper 6 inches of sediments at Station 7, however, were determined to be 2,825 ppm (0 to 3 inches) and 39,940 ppm (3 to 6 inches) -- or 45 to 110 times as great as those at the stations upstream along the drainageway.

These data indicate that the mercury-rich material that caused the extreme contamination of the sediments at Station 7 did not move across the sediments at Stations 3, 4, or 6. This, in turn, means that (1) the extremely high concentrations of mercury at Station 7 reflect the discharge of effluents from the former chemical manufacturing plant through a route that was different from the existing system, but which terminated at the same point; or (2) the former routing was similar to the modern routing, but when the buried culverts were installed (allegedly during the 1960's) the ditches that were to remain open were widened, deepened, or otherwise excavated; or (3) there is a source of mercury-rich materials in the culvert between Station 6 and Station 7; or (4) mercury-rich materials were deposited (i.e., dumped) at Station 7. If explanation (1) or (2) were correct, the original source of the contaminant has been abated by the closure of the manufacturing plant formerly on the Subject Site. If explanation (4) were correct, presumably the contamination occurred through one event, or it was the act of an irresponsible person who may have been employed at the former plant, but now is gone. If explanation (3) were correct, it would be logical to suspect that a concrete block structure about 450 feet southeast of Station 6, which is an access shaft to the culvert, and may have been used by an irresponsible person as a convenient avenue for the disposal of waste materials. There is a catch basin, or sediment trap, associated with this access shaft (VE-17), and it may contain an accumulation of mercury-rich materials.

5.1.4. Mercury in Surface Water

The standard for the allowable maximum concentration of mercury (total) in the surface waters (unfiltered) of the State of New Jersey is 5 ppb (Table 14). This standard was exceeded by concentrations detected in seven of the thirteen samples of water collected at Station 6 on the Subject Site on 19 May 1977 (Table 11); and it was exceeded in one of the thirteen samples from Station 6 on 8 June 1977 (Table 12). In determinations of water collected at the outfall point of the Subject Site (Station 7), the standard was exceeded by levels in six of the eleven valid samples collected on 8 June 1977 (Table 12).

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Concentrations of mercury in excess of 0.1 ppb were detected in many of the samples that were collected from Stations 1 and 2, which are located in a paved swale between the buildings on the property of the United States Life Insurance Company and in the property of Wolf Realty, and from Station 5, which is located in an unlined ditch that is situated to the southwest of the building on the Wolf Realty property. These concentrations are believed to have been produced by the entrainment of sediments during the removal of samples from the shallow water. Similarly, the high concentrations of mercury in samples collected at Station 4 (1720 hours), Station 7 (1850 and 1955 hours), Station 8 (1845 hours), and Station 9 (1850 hours) on 8 June 1977 are believed to reflect the entrainment of sediments during the collecting operation (Table 12).

The presence of mercury in samples of water taken during periods of low water, when water flows from the Site (from Station 6 to Station 7), demonstrates that mercury from the Site is entering Berrys Creek (Table 11, entries annotated with the word "Eastward"). All of the samples of water that were collected during this investigation were obtained on days when no rain was falling. Stormwater drainage from areas with mercury-rich soil and the roiling of sediments in the channels by raindrop impact and by more rapid flows will mobilize sediments, and will to increase the amount and the concentration of mercury in the water.

The maximum concentration of mercury (total) in surface waters should not exceed 0.1 ppb to ensure protection of marine aquatic life (Table 14). All measurements from Stations 4, 6, and 7 on the Subject Site and all measurements in Berrys Creek at Stations 8 and 9 exceeded the concentration recommended (Tables 11, 12, and 13). The aquatic environment on the Subject Site and in its vicinity, therefore, is considered to be hazardous to the survival and reproduction of fish and other marine and freshwater aquatic organisms.

5.2. Arsenic

5.2.1. Arsenic in the Soil

The concentrations of arsenic in soil in the United States generally range from 0 ppm to 120 ppm, and the average concentration is about 5 ppm (Curry and Gigliotti 1973). The soils at several stations on the Velsicol property had levels of arsenic that appear to be less than to only slightly greater than the nationwide average (Stations W1, W2, W3, and W6 in Table 5; Stations 9S, 11S, 14S, 15S 18S, 19S, and 23S in Table 6). These concentrations probably represent the regional background level of arsenic.

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The soils at other stations apparently have been enriched with arsenic. The highest concentrations were observed on the Velsicol property at Station 4S (58 ppm, 64 ppm) and at Station 21S (49 ppm, 82 ppm). At Station 22S, which is adjacent to the Site, the observed concentration of arsenic in the soil between 6 to 12 inches in depth was 148 ppm. These three stations are aligned, and are associated with a ditch through which industrial wastewater is discharged to Berrys Creek. This geographic relationship suggests that the discharge may be a source of arsenic.

The concentrations of arsenic were determined in samples of soil collected during July 1974 from the Wolf Realty property (Table 15). The results indicate that levels of arsenic as high as 35.9 ppm were observed, and that the average concentration in the soil was 12.0 ppm. Although this concentration exceeds the national mean, it is not considered to be of special concern.

Except for the concentrations observed at Stations 4S and 21S, the Site does not appear to be significantly contaminated by arsenic.

5.2.2. Arsenic in Groundwater

The US-EPA maximum contaminant level for arsenic in drinking water at the point where such water enters the distribution system is 0.05 mg/l, or 50 ppb (Table 14). The concentrations of arsenic in filtered samples of water drawn from ten wells on or near the Subject Site on 13 July 1977 were less than 20 ppb (Table 9). These data do not indicate that dissolved arsenic is reaching the groundwater on the Subject Site in concentrations that are likely to be hazardous to human health or to the aquatic environment.

5.2.3. Arsenic in Channel Sediments

To provide a standard for comparisons, information on the concentrations of arsenic in the sediments of Lake Erie was employed (Walters and others 1974). Within 4 inches of the surface, the concentrations of arsenic at five localities ranged from 2 ppm to 8 ppm. The concentrations of arsenic in sediments from the stations on the Subject Site generally are within this range (Table 10) and, therefore, are considered not to represent a hazard to aquatic organisms.

At the outfall point (Station 7) and at Stations 8 and 9 on Berrys Creek, concentrations of arsenic in the uppermost 6 inches of sediment are as great as 35 ppm to 56 ppm. These values appear to be excessive, and are considered to represent a hazard to aquatic organisms. The variation of concentrations with depth from station to station (Table 10) indicate that the site was a source of enrichment in the past, but that the source has been abated.

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5.2.4. Arsenic in Surface Water

The standard for the allowable maximum concentration of arsenic in the surface waters of the State of New Jersey is 50 ppb. This limit also is considered adequate to protect aquatic organisms (Table 14). Except for one sample from Station 2, the concentrations of arsenic in samples of water from the Subject Site and its vicinity did not equal or exceed the State standard (Tables 11, 12, and 13). Sediments entrained in the sample from Station 2 probably resulted in the high concentration that was observed.

5.3. Cadmium

5.3.1. Cadmium in the Soil

The range of concentrations of cadmium in soil, other than in mineralized areas, generally is 0.1 ppm to 0.5 ppm (Curry and Gigliotti 1973). On the basis that 0.5 ppm represents the maximum natural concentration of cadmium in the soil, the soils within 24 inches from the surface at all stations surveyed during this investigation have been enriched with cadmium to varying degrees.

The highest concentration of cadmium on the Velsicol property (120 ppm) was observed in materials from a depth of 12 to 14 feet at Station W4 (Table 5). At the same station, the concentration of cadmium in materials from a depth of 10 to 12 feet was 26 ppm. A buried accumulation of cadmium also was detected at Station W2. The concentrations of cadmium at depths of 6 to 8 feet and 8 to 10 feet at Station W2 were 26 ppm and 36 ppm, respectively.

The highest levels of cadmium observed in soil within 24 inches of the surface were at the following stations: 4S (78 ppm, 72 ppm), 7S (19 ppm, 13 ppm, and less), 8S (33 ppm, 14 ppm, and less), 11S (27 ppm and less), 12S (86 ppm and less), 13S (18 ppm, 10 ppm, and less), 16S (18 ppm, 15 ppm, 12 ppm, and 13 ppm), 18S (29 ppm and less), and 21S (43 ppm and less).

Levels of cadmium in stations near the Subject Site ranged from less than 0.3 ppm to 0.9 ppm at Station W8, and from 1.3 ppm to 4.2 ppm at Stations S1, S2, S3, S5, S6, and S20. The marsh soil at Station S22 contained 31 ppm cadmium in the surficial 6 inches and 71 ppm cadmium at a depth of 6 to 12 inches (Table 5).

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Analyses of samples of soil collected during July 1974 (Table 15) indicate that the average concentration of cadmium is 5.9 ppm on the Wolf Realty property. At a maximum, therefore, the total amount of cadmium present on the Wolf Realty probably was no more than 1 ton.

The presence of cadmium in unnaturally high concentrations in soils on the site does not appear to pose an immediate hazard to human health. Most health concerns in regard to cadmium are related to industrial exposures (Wagner 1973). Cadmium also is absorbed and cumulated by plants, but it seldom passes to the human food chain in quantities or at concentrations that are injurious. If plants on the Site are cumulating cadmium, however, they may be hazardous to herbivorous wildlife.

5.3.2. Cadmium in Groundwater

The US-EPA maximum contaminant level for cadmium in drinking water at the point where such water enters the distribution system is 0.010 mg/l, or 10 ppb (Table 14). Based on this standard, which was established to protect human health, the concentrations of cadmium in filtered samples of water collected on 13 July 1977 indicate that the groundwater at Station W6 (13 ppb cadmium) is contaminated. The groundwater at four other stations contains cadmium in concentrations that suggest a source of contamination: Station WE (5.6 ppb), Station W5 (6.8 ppb), Station W8 (9.0 ppb), and Stations WS (9.0 ppb). More intensive testing of samples from these wells is necessary to characterize the water more adequately. Well 2 and Well 4, at sites known to have high concentrations of cadmium in the soil, also should be examined more intensively.

Concentrations of cadmium in natural marine and freshwater sediments range from 0.2 ppm to 5.0 ppm. In sediments exposed to industrial contamination, concentrations as great as 12 ppm have been observed (Bruland and others 1974; Iskandar and Keeney 1974; Mathis and Cummings 1973; Walters and others 1974).

5.3.3. Cadmium in Channel Sediments

The sediments at Stations 3 and 6 on the Subject Site contain cadmium at background levels (Table 10). The concentrations in sediments from 6 to 9 inches at Station 4 and from 3 to 6 inches at Station 5 were considerably higher than the natural levels (40 ppm and 45 ppm, respectively).

The concentrations of cadmium in the sediments in Berrys Creek were well above the natural background levels at Stations 7, 8, and 9 (Table 10). The levels in the sediments at the outfall point ranged from 12 ppm to 19 ppm, and the materials nearest the surface contained 19 ppm cadmium. The surficial sediments at the stations upstream and downstream from the outfall point contained 58 ppm and 24 ppm cadmium, respectively. These data, in association with determinations that indicate that the levels of cadmium in the surficial sediments at Stations on the Site range from 0.6 ppm to 4.6 ppm, suggest that the enrichment of Berrys Creek largely may be produced by a source other than the Subject Site.

Cadmium in the sediments of Berrys Creek almost certainly represent a hazard to the aquatic biota. Although the soils on the Subject Site are enriched with cadmium, the data from the investigations of the channel sediments do not indicate that particulate cadmium now is being transported rapidly from the Site.

5.3.4. Cadmium in Surface Water

The standard for the allowable maximum concentration of cadmium in the surface waters of the State of New Jersey is 10 ppb. The limit recommended to protect marine aquatic life is 5 ppb (Table 4). None of the thirteen samples of water collected at Station 6 during a tidal cycle on 19 May 1977 contained cadmium at a concentration greater than 2.4 ppb (Table 11).

The State standard was exceeded during three of the four observations at Station 7 (the discharge point) on 13 July 1977. The concentrations at these times were 18 ppb, 19 ppb, and 11 ppb (Table 13). The simultaneous concentrations at the upstream and downstream stations on Berrys Creek (Stations 8 and 9), respectively, were: 20 ppb/12 ppb; 15 ppb/7.7 ppb; and 8.4 ppb/ 3 ppb. The first of the three observations was made at a time of high water, and the other two were made during a period of falling water levels. The apparent discharge of cadmium from the Site, therefore, probably was produced by water from Berrys Creek returning to the Creek as the tide receded.

Based on the data available, it does not appear that excessive concentrations of cadmium are entering the surface waters from the Site.

5.4. Lead

5.4.1. Lead in the Soil

The geometric mean concentration of lead in the soils and surficial rocks of the United States is 16 ppm (Shacklette and others 1971). Natural soils in many areas have concentrations of lead as great as 150 ppm, and the highest level observed in 863 localities was 700 ppm. In the lowest increments of the well borings, the concentrations of lead range from 5 to 17 ppm, and probably represent the local background level (Table 5).

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The results of analysis of well cores from the Velsicol property, taken to depths as great as 18 feet, indicate that there is a concentrated deposit of lead at Station W2 at a depth of 6 to 10 feet (12,900 ppm to 14,300 ppm, Table 5). The soil materials from other cores from the property contain concentrations of lead that range to as great as 1,400 ppm (Station 4).

At nearly all increments in depth, the soils from all of the shallow-test stations on the Velsicol property contain lead at concentrations which exceed the background level (>16 ppm). Concentrations of lead in samples from Stations S10, S11, S13, S17, and S19 exceed 1,000 ppm (Table 6).

Soil on the Wolf Realty property was sampled during July 1974 (Table 15). The results of the analyses indicate that the average concentration of lead in the soil is about 158 ppm, or ten times background.

At other stations in the surrounding area, the concentrations of lead in samples of soil generally ranged from 116 ppm to 594 ppm (Table 6). At Station 1S, near Teterboro Airport, soil at a depth from 6 to 12 inches contained 5,710 ppm lead.

Lead poisoning in human beings usually is the result of industrial exposure, the ingestion of lead-based paint, or the ingestion of foods or beverages contaminated with lead from improper containers. Lead inhaled from automobile exhausts also is known to produce higher than normal concentrations in the blood. No reason is apparent, however, to suggest that the presence of soil enriched with lead is a significant, direct threat to human health.

Lead is toxic to wildlife. The most commonly cited example of toxicity is that produced in waterfowl that ingest spent lead shot during their feeding activities. This results in lead poisoning and death. Lead in such pure form, in the shape of pellets similar in size to seeds, and in mixture with attractive natural foods was not observed on the Site. Although it is not likely that birds or other wildlife would accidentally ingest large amounts of lead from the site, individuals with high body loads of lead acquired elsewhere could be exposed to potentially toxic or lethal doses.

5.4.2. Lead in Groundwater

The US-EPA maximum contaminant level for lead in drinking water at the point where such water enters the distribution system is 0.05 mg/l, or 50 ppb (Table 14). The concentrations of lead in filtered samples of water drawn from ten wells on or near the Subject Site on 13 July 1977 were less than 10 ppb (Table 9). These determinations do not indicate that dissolved lead is reaching the groundwater on the Subject Site in concentrations that are likely to be hazardous to human health or to the aquatic environment.

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5.4.3. Lead in Channel Sediments

Concentrations of nickel in natural sediments range from 0.1 ppm to 51 ppm. Observed concentrations in sediments exposed to industrial contamination range to as great as 167 ppm (Bruland and others 1974; Iskandar and Keeney 1974; Mathis and Cummings 1973).

Concentrations of lead in the sediments at Station 3, which is on the Site, and at Station 9, which is in Berrys Creek, are within the range of natural background (Table 10). At least at one increment of depth, and in the surface at all but Station 5, the sediments at Stations 4, 5, 6, and 7 (outfall point), and Station 8 (upstream) in Berrys Creek, are substantially enriched with lead. The concentrations in the surficial layer are 155 ppm and 162 ppm at Stations 4 and 6 on the Site, and 480 ppm and 252 ppm at Station 7 (outfall point) and Station 8 in Berrys Creek.

The high concentrations of lead in the channel sediments are not beneficial to aquatic organisms. Depending on the form of lead present, the materials may be toxic to the organism.

5.4.4. Lead in Surface Water

The standard for the allowable maximum concentration of lead in the surface waters (unfiltered) of the State of New Jersey is 50 ppb. This concentration also is considered to be the threshold level for the appearance of damage to aquatic organisms (Table 14). The concentrations of lead in three of the thirteen samples collected hourly at Station 6 on 19 May 1977 exceeded the standard (57, 61, 71, and 82 ppb; Table 11). Four samples of water were collected at the outfall point (Station 7) and at each of the two stations on Berrys Creek on 13 July 1977. In none of these samples did the concentration of lead exceed the State standard.

Based on the observed levels in water collected at Station 6, lead from the Subject Site appears to migrate to Berrys Creek. This opinion is supported by the fact that the concentrations of lead in the sediments at the outfall point (Station 7), and at Station 6 on the Site, are higher than the concentrations in sediments at both or at one of the stations in Berrys Creek (Table 10).

Lead is not essential to the metabolism or growth of human beings or other animals, but the metal accumulates in bone and tissue. No biological benefit from the ingestion or absorption of lead is known. Acute lead poisoning is rare in human beings, but chronic lead toxicity occurs in sensitive individuals with a daily intake of 1 mg or less of lead (National Research Council 1977). Chronic lead toxicity in aquatic organisms is known to occur when the concentration of lead in the water remains at or greater than 50 ppb (Committee on Water Quality Criteria 1972). The levels observed at Station 6 are hazardous to aquatic biota.

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Pulses of lead from the Site, or intermittent incursions of lead-rich water at times of high tides may be responsible for the irregularities in the concentrations of lead in samples collected on 19 May and 13 July 1977. More frequent sampling will be necessary to identify the source of these loadings.

5.5. Nickel

5.5.1. Nickel in the Soil

The geometric mean concentration of nickel in the soils of the United States is 13 ppm. Examples from a number of localities contain nickel in concentrations as high as 70 ppm, and the highest concentration observed at 862 sites was 700 ppm (Shacklette and others 1971). The concentrations of nickel in soil materials from depths as great as 14 feet at Station W8, near Park Place East, ranged from 7 ppm to 14 ppm, and are considered to represent the regional background levels of nickel (Table 5).

The soil at Stations W1 through W6 on the Velsicol property is moderately enriched with nickel to depths that range from 4 to 18 feet (Table 5). Samples from all depths at Station W7 are within the range of regional background levels.

Samples of soil within the uppermost 12 to 24 inches were obtained from sixteen stations on the Velsicol property (Table 6). The results of the analyses of these samples demonstrate that nickel enrichment is general throughout the property. They also indicate that more nickel and/or materials with higher concentrations of nickel have been placed on the southwest half of the property, particularly at Stations 16S, 12S, 19S, 11S, 13S, 17S, and 7S.

Investigations made during July 1974 (Table 15) provide a description of the nickel in soils on the Wolf Realty property. The maximum concentration of nickel found was 1,076 ppm. The average concentration of nickel in the soil was 92 ppm. Although this concentration is higher than the average for soil in the United States, the level is not considered to be of concern in regard to the health of human beings, aquatic biota, or upland wildlife.

The concentrations of nickel on the Subject Site are considerably higher than the regional background level, but none exceeds the highest concentrations observed in natural soil and rock in the United States. The form in which the nickel occurs on the Site is unknown. Nickel dust, when inhaled, can produce bronchial cancer in human beings and in animals. Several compounds of nickel also are toxic. The material is considered to be a potential hazard to human health and to wildlife.

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5.5.2. Nickel in Groundwater

The reference level selected for use in this investigation to gage the threshold concentration of nickel that may represent a hazard to human health is 5,000 ppb (Table 14). The concentrations of nickel in filtered samples of water that were drawn from the ten wells on or near the Subject Site on 13 July 1977 were less than 100 ppb. These data do not indicate that nickel is entering the groundwater in concentrations that are likely to be hazardous to human health or to the aquatic environment.

5.5.3. Nickel in Channel Sediments

Concentrations of nickel in natural sediments range from 2.5 ppm to 60 ppm. Observed concentrations in sediments exposed to industrial contamination range to 124 ppm (Bruland and others 1974; Iskandar and Keeney 1974; Mathis and Cummings 1973).

In the sediments from the ditches on the Subject Site (Stations 3, 4, 5, and 6), the concentrations of nickel generally range from 3.3 ppm to 30 ppm, and are within the range of background levels (Table 10). A sample from 3 to 6 inches in the core from Station 5, however, contains 141 ppm nickel. The sediment at the outfall point (Station 7) has a similar concentration (146 ppm) at the same position, and contains 81 ppm nickel in the increment from 0 to 3 inches. At the two stations in Berrys Creek (Stations 8 and 9), the concentrations of nickel in the sediments range from 21 to 63 ppm and from 17 to 47 ppm, respectively, and are within the range of background levels.

Except in the sediments at the outfall point and at Station 5, the concentrations of nickel in the sediments on the Subject Site appear to be normal.

5.5.4. Nickel in Surface Water

No finite standard for the maximum allowable concentration of nickel in the surface waters of the State of New Jersey has been promulgated. The criterion employed in this evaluation is the hazard threshold for aquatic biota, which is 100 ppb (Table 14).

Concentrations of nickel in thirteen samples of water that were collected from Station 6 at intervals of 1 hour on 19 May 1977 did not exceed 20 ppb (Table 11). Four samples of water were collected from Station 7 (outfall point) on 13 July 1977. The concentrations of nickel in all four samples were less than the threshold sensitivity of 100 ppb employed in the analyses (Table 13). The levels of nickel in eight samples drawn from Berrys Creek at Stations 8 and 9 on 13 July 1977 also satisfied the criterion.

These tests indicate that nickel was not present in the surface waters in excessive concentrations during the periods of observation in May and July 1977.

5.5. Zinc

5.6.1. Zinc in the Soil

The geometric mean concentration of zinc in soils and surficial rock in the United States is 44 ppm (Shacklette and others 1971). Concentrations of zinc as high as 370 ppm are not uncommon. The concentrations of zinc in soil samples from depths that range variably from 6 to 16 feet at Stations W1 and W3 through W8 suggest that the local background concentration of zinc is in the range from 23 ppm to 72 ppm (Table 5).

The analytical results demonstrate that the soils on the Velsicol property have been enriched by additions of zinc. Concentrations as high as 28,832 ppm were detected in samples of surficial materials (Station 4S; Table 6). Materials with concentrations greater than 1,000 ppm are known to be present at every station on the Velsicol property, except Station W7.

On the Wolf Realty property, an investigation during July 1974 indicated that the maximum concentration of zinc in the soil is 76,500 ppm (Table 15). The average concentration is about 7,600 ppm, or 170 times background. At this concentration, zinc does pose a hazard to species of wildlife that inhabit the soil. Except as it is reflected in the groundwater and surface water, however, the concentration probably does not represent a direct or potential threat to aquatic organisms or terrestrial wildlife that are free-ranging.

5.6.2. Zinc in Groundwater

The recommended maximum allowable concentration of zinc in drinking water is 5,000 ppb (Table 14). The concentrations of zinc in filtered samples of water drawn from the nine wells on or near the subject site on 13 July 1977 ranged from 20 ppb to 360 ppb (Table 9). In two samples of water from the South Well (Station WS), the concentrations of zinc were 2,800 ppb and 4,700 ppb.

Although the observed concentrations of zinc in the groundwater at Station WS approach the level of the recommended standard, they do not indicate that zinc poses a threat to human health. The standard is based on aesthetic considerations, specifically on taste, and is known to be no more than 10% of the concentration that may result in illness in human beings.

These data demonstrate the presence of dissolved zinc in substantial concentrations in groundwater on the Subject Site. Based on the unnaturally high concentrations of zinc in the soil on the Site (Section 5.6.1.), it is reasonable to conclude that the zinc is mobilized from the soil by groundwater that is in contact with zinc-rich materials and/or that zinc is mobilized from the soil in zone or aeration and is leached to the water table.

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5.6.3. Zinc in Channel Sediments

Concentrations of zinc in natural sediments range from 6 ppm to 180 ppm. Observed concentrations in sediments that are subject to contamination from industrial sources range to 340 ppm (Bruland and others 1974; Iskandar and Keeney 1974; Mathis and Cummings 1973).

Except at Station 3, the concentrations of zinc in the sediments in the ditches on the site substantially exceed the background levels (Table 10). In the surficial sediments at Station 4 and in the increment from 3 to 6 inches in depth at Station 5, the concentrations of zinc are 2,116 ppm and 5,187 ppm, respectively. Although the concentration in the surficial sediment at Station 6 is considerably lower (428 ppm), it is more than twice that of the background level.

The concentrations of zinc at all depths in the sediments at the outfall point (Station 7) exceed 2,000 ppm, and from 3 to 6 inches in depth the concentration is 8,615 ppm (Table 10). The sediments in Berrys Creek at Stations 8 and 9 are less contaminated than are those at Station 7, but the concentrations in the surficial materials are more than four times as great as the highest background level.

The presence of zinc in such high concentrations in the sediments of the ditches on the Subject Site and in the channel of Berrys Creek is a hazard to aquatic organisms and wildlife.

As noted in Section 5.6.4. and discussed more fully in Section 5.1.4., certain conditions resulted in disturbances to the sediments and the entrainment of sediments in certain samples of water. The analytical results for those samples are omitted from considerations of the undisturbed character of the surface waters. The results, however, do demonstrate the significant degradation in the chemical quality of the water that can be produced by suspended particulate matter of local origin. The analyses of the sediments demonstrate that these particulates are contaminated with various metals.

In regard to zinc, the results of determinations on samples collected on 8 June 1977 from Stations 1 and 2 are of interest (Table 12). Stations 1 and 2 are connected hydraulically with Station 3. The concentration of zinc in the water at Station 3 can be assumed to be the concentration at Stations 1 and 2 in the absence of disturbance. To be conservative, the concentration observed at 2030 hours (40 ppm), is considered to be the uniform background. The effect of the entrainment of sediments can be estimated by subtracting 40 from each analytical determination at Stations 1 and 2 that exceeds 40 ppm. These calculations indicate that the presence of sediments may have increased the concentrations of zinc in the water column by as much as 1,460 ppm.

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5.5.1. Zinc in Surface Water

No finite standard for the maximum allowable concentration of nickel in the surface waters of the State of New Jersey has been promulgated. The criterion employed in this evaluation is the hazard threshold for aquatic biota, which is 100 ppb (Table 14).

In all samples of water that were collected hourly for thirteen hours on 19 May 1977 at Station 6, the criterion for zinc was exceeded by 40% to 130% (Table 11).

A similar program of sampling was executed on 8 June 1977 at most of the stations on and near the Site (Table 12). The results of certain analyses are not considered in characterizations of the quality of the surface water owing to the entrainment of sediments during the collecting operation. This is discussed in Section 5.1.4. The following description omits the invalid samples.

The observed concentrations of zinc in samples of water from Stations 3 and 4 ranged from 20 ppb to 100 ppb, and did not exceed the criterion (Table 12). In nine of the thirteen samples of water from Station 6, the concentration of zinc satisfied the criterion (40 ppb to 90 ppb), the levels of zinc in four samples ranged from 120 to 130 ppb. At the outfall point (Station 7), levels of zinc in the eleven valid samples ranged from 110 ppb to 230 ppb, and none satisfied the criterion. At Station 8, which is in Berrys Creek upstream from the outfall point, the observed concentrations of zinc ranged from 40 ppb to 90 ppb in six samples and from 110 to 140 ppb in the six other valid samples. Downstream from the discharge point, at Station 9, the concentration of zinc in two samples (70 ppb and 100 ppb) satisfied the criterion. The levels of zinc ranged from 110 ppb to 150 ppb in the other ten valid samples (Table 12).

On 13 July 1977, samples of water were collected at Stations 7, 8, and 9. The initial sample was obtained during a period of high water. Three other samples were drawn from each station as the tide receded nearly to a low slack stage. The concentration of zinc in the first sample from each station was 80 ppm (Table 13). In the three other samples from Station 7, the levels of zinc exceeded the criterion in two (230 ppb, 140 ppb) and met the criterion in one (100 ppb). One of the six samples obtained later in Berrys Creek contained zinc in a concentration greater than the criterion (160 ppb).

The information reviewed above demonstrates that zinc moves from the Subject Site into Berrys Creek by means of the surface water drainage system. Analyses of filtered samples of well water (Section 5.6.2.) demonstrated the presence of soluble forms of zinc at concentrations as high as 4,700 ppb in the groundwater on the Subject Site.

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Analyses of channel sediments demonstrated that these materials contain zinc in unusually high concentrations (Section 5.6.3.). The accidental disturbance of the sediments and the entrainment of the sediments in samples of water demonstrated the ready mobility of the sediments and the fact that they become transformed to suspended particulates in the water column.

These two series of related facts indicate that zinc may move through the drainage system either in a dissolved form or in particulate form, or it may move simultaneously in both the dissolved and particulate forms. In either form, the zinc is a hazard to aquatic biota and wildlife at concentrations greater than 100 ppb.

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6. SUMMARY OF FINDINGS AND RECOMMENDATIONS

6.1. Findings

6.1.1. Soil

The soil throughout the Subject Site has been enriched extraordinarily with mercury (to 123,000X background levels). The available measurements indicate that at least 126 tons of mercury are present on the Wolf Realty property, and at least 160 tons of mercury are contained in 19 acres of the Velsicol site. Enrichments with lead (to 890X background levels) and zinc (to 655X background levels) also are extreme and relatively uniform. Cadmium enrichment is evident throughout the site (to 240X background levels), but the concentrations vary irregularly from place to place. Enrichment by nickel is moderate (to 18X background levels), and materials with the highest concentrations are confined to the southwestern half of the Site. Concentrations of arsenic are high at two stations in the southwestern section of the Site (to 16X background levels), but the levels are near background throughout the remainder of the Site.

6.1.2. Groundwater

Dissolved mercury is present at a concentration in excess of the drinking water standard in the East Well (4.3 to 8.8 ppb). The concentration of mercury satisfies the standard, but is measurable, in the South Well (0.8 to 0.9 ppb). Dissolved cadmium (13 ppb) exceeds the drinking water standard in Well 6, and it is present at relatively high concentrations (5.6 to 9.0 ppb) in the East Well, the South Well, Well 5, and Well 8.

The concentration of zinc in the South Well (2,800 to 4,700 ppb) is high, but does not exceed health standards. The observation suggests that zinc may be highly mobile in the vicinity of the well.

6.1.3. Channel Sediments

Sediments in the drainage ditches on the subject site are contaminated uniformly and substantially with mercury (882X background level). Zinc (29X background level) and lead (4.7X) are present in abnormal concentrations throughout most of the drainage system. The concentrations of cadmium (9X background levels) are high at two stations. Nickel and arsenic both are within their background ranges on the Site.

Mercury (89,162X) is extraordinarily concentrated at the discharge point. The levels of zinc (48X), lead (11X), arsenic (7X), and nickel (2.4X), at the discharge point are substantially higher than normal. In other sections of Berrys Creek, mercury (993X), cadmium (21X), lead (11X), arsenic (5X), and zinc (5X) are above background levels.

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6.1.4. Surface Water

Concentrations of mercury (4.8X standard) and lead (1.6X standard) in waters on the site or at the outfall exceeded the applicable State standards during this investigation. All concentrations of mercury observed at relevant stations exceeded the level recommended to avoid harm to aquatic organisms.

In 76% of the samples examined, the concentrations of zinc exceeded (1.3X criterion) the level considered to be hazardous to aquatic biota.

Concentrations of arsenic and cadmium at stations on the Subject Site satisfied the State standards. Levels of arsenic at Stations on Berrys Creek also were less than the concentration considered to be hazardous to aquatic life. Concentrations of cadmium in Berrys Creek, however, exceeded the biological safety limit repeatedly.

6.2. Recommendations

6.2.1. Specific Evaluation of the Containment System.

The building that now occupies the property owned by Wolf Realty was designed and constructed to act as a containment system for mercury-rich soils. Allegedly, soils with the highest concentrations of mercury were scraped before the erection of the warehouses and placed in the area now enclosed by the building.

The concentration of dissolved mercury in a sample of water that was drawn from a well within the containment system during March 1977 was 66 ppb. Tests made during this investigation revealed high concentrations of dissolved mercury in the groundwater at two wells adjacent to the building. No dissolved mercury was detected during tests on eight other wells on the Site. One of these wells (#6) is approximately 100 feet south-southeast of the East Well. These data indicate that the containment system is not functioning as intended, and is a source of mercury contamination.

The escape of mercury from the Wolf Realty property must be prevented to protect the delicate environmental balance of Berrys Creek, the Hackensack Meadowlands District, and other areas on the Newark Bay-Raritan Bay estuarine system. It is recommended, therefore, that a revised version of Alternate 4 that was formulated for the Rovic Construction Company, Inc., by Joseph S. Ward, Inc. (WV-25), be implemented.

Alternate 4 was intended to be a supplement to the construction of the building on the Wolf Realty property as a mercury containment system. It is described in a letter of 29 January 1975 by Mr. Thomas J. Scheil, P.E., as follows:

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Buried culverts, particularly the section between Stations 6 and 7, probably contain accumulations of sediments that are resuspended by the actions of the tides, by stormflow events, and by other agents. These culverts should be excavated, inspected carefully, cleaned, and removed. All other ditches on or adjacent to the properties of the United States Life Insurance Company, Wolf Realty, and the Velsicol Chemical Corporation should be cleaned by excavating and removing contaminated sediments. The drainage system that serves these properties should be revised, and the discharge of runoff should be rerouted to the ditch that extends generally between Stations 7S and 22S. The existing drainage system that discharges at Station 7 should be sealed. All ditches used in the revised drainage system should be surfaced with an impermeable liner, such as concrete. No buried culverts should be designed into the system,

The channel of Berrys Creek also should be cleaned with a small suction dredge. Until more comprehensive restoration plans are devised, the area from the West Riser Ditch Tide Gate to a point upstream at which the levels of contamination are at or near background should be cleaned. Excavations made during the removal of the culverts could be considered for use as basins to accept spoil dredged from Berrys Creek.

The Tide Gate should be reconstructed before, or concurrent with, the restoration dredging of Berrys Creek. The repairs to the tide gate are essential to protect the West Riser Ditch (upper Berrys Creek) from recontamination by mercury-rich sediments that are carried upstream by the tides. The tide gate also will prevent high waters from surcharging the drainage system on the Subject Site. To provide further protection to the Site, the new drainage system also should be equipped with a tide gate at the point where it joins the existing ditch between Stations 7S and 22S.

6.2.3. Termination of Dumping on the Velsicol Property

Dumping, whether by authorization or not, has continued on the Velsicol property. All authorized dumping should be discontinued, and the site should be posted and fenced to prevent or minimize unauthorized dumping and to prevent trespassing. Conspicuous signs should be erected on the upland boundaries and along Berrys Creek to warn possible trespassers of the hazards that exist on the site.

6.2.4. Velsicol Property: Alternative 1. Removal of Mercury

There are at least 160 tons of mercury on the 19 acres of the Velsicol property that were investigated during this project. To protect Berrys Creek, the Hackensack River, and the remainder of the Newark Bay-Raritan Bay estuarine system from further contamination, the mercury-rich soils on the Velsicol property should be removed and decontaminated. The mercury that is recovered can be returned to the industrial/commercial market for proper and productive use.

The soil in all areas known to have been used as chemical waste dump sites, and in any other areas in which the concentrations of mercury exceed 500 ppm should be excavated and decontaminated. The remaining soil should be recontoured to provide a slope away from Berrys Creek. If the property is improved, as much as possible of the surface should be covered with impervious pavement or structures. If the property is not improved, the surface should be planted to develop a complete, dense cover of vegetation, such as a thick lawn. This will minimize the movement of the contaminated soil by stormwater and by wind.

Plans for any alteration of the site and/or for the installation of any improvement to the property should be submitted to the Department of Environmental Protection. The written approval of the Department should be made a mandatory requirement for any such alterations or improvement in perpetuity. This condition, and a notice concerning the hazard contained on the site, should be entered against the deed in the Office of the County Clerk.

6.2.5. Velsicol Property: Alternative 2. Containment of Mercury

If it is not feasible to excavate the severely contaminated soil and reclaim mercury from it, the mercury must be securely contained within the site. The soil in areas that are known to have been used as chemical waste dump sites, and the soil in any other areas in which the concentrations of mercury exceed 500 ppm should be excavated and moved to the area between Stations 10S and 13S. The severely contaminated materials then should be surrounded by a cutoff wall, based on the impermeable varved clay, and enclosed by a concrete structure similar to the foundation of the building on the Wolf Realty property.

The remainder of the site should be recontoured to provide a slope away from Berrys Creek. The surface then should be paved or planted with a dense cover of vegetation to hold the soil.

Plans for any alteration of the site and/or for the installation of any improvement to the property should be submitted to the Department of Environmental Protection. The written approval of the Department should be made a mandatory requirement for any such alteration or improvement in perpetuity. This condition, and a notice concerning the hazard contained on the site, should be entered against the deed in the Office of the County Clerk.

6.2.6. Monitoring for the Wolf Realty Property

Regardless of the method used to provide a secure containment for mercury on the Wolf Realty property, a program of regular monitoring should be instituted to verify the performance of the system. This program should utilize a pattern of observation wells placed at intervals of 100 feet along the boundary of the property, four wells near the midpoints of the walls inside the building, and two wells near Stations 1 and 2. Recording

gauges should be installed to track changes in the levels of one well inside the building, the well at Station 1, one well at the northeast corner, and one well near the southeast corner. Manual observations of the levels in all of the wells should be made at least one time each month.

Initially, tests for mercury and other constituents in filtered samples of water from these wells should be made one time each month. After 12 months, if the results of the analyses do not indicate that mercury is continuing to move from the property, the frequency of the analyses for mercury can be reduced to one set of samples each three months (quarterly). The actual scheduling, of course, should be determined by the Department of Environmental Protection (NJ-DEP).

The selection by the property owner of the persons or firm to conduct this monitoring should be subject to the approval of NJ-DEP. Timely reports on the results of the monitoring, including water levels and concentrations of mercury, should be submitted to NJ-DEP. The Department also should evaluate these data to determine whether or not mercury is continuing to move from the property. Any change in the schedule of sampling, the location of observation wells, the number of observation wells, the parameters to be measured, or other procedures should be made only upon the recommendation of NJ-DEP or with the approval of the Department.

6.2.7. Monitoring for the Velsicol Property

Regardless of the method used to remove or contain the severely contaminated soil on the Velsicol property, a program of regular monitoring should be instituted to verify that the method is successful in preventing the escape of hazardous materials from the property. This program should utilize observation wells to monitor the quality and flow of groundwater and stations on ditches, at the discharge point, and in Berrys Creek to monitor the quality of the surface waters. The purpose of the program is to ensure that no significant pollution can leave the Velsicol property without detection, and to provide an instantaneous warning if a release should occur.

The program of monitoring should be devised and detailed in collaboration with NJ-DEP. It is recommended, however, that automatic equipment for water quality monitoring be installed in the drainage system and on Berrys Creek. These monitors, if equipped with alarms, would warn of unexpected breakthroughs, embankment failures, and similar emergencies without need for a resident monitor.

Contingency plans should be developed so that the necessary emergency personnel and equipment can be mustered to contain and control any problem. Written reports on the results of the monitoring should be prepared in a timely way and submitted to DEP and any other agencies with jurisdiction or special expertise.

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US-EPA. 1975. [National interim primary drinking water regulations.]
40 CRF 141; 40 FR 59565, 24 December 1975; amended by 41 FR 28402,
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